DCN 1634

Defense Base Closure and Realignment (BRAC)

Commission Visit

Rebecca G. Cox, Commissioner

Monday, 27 March 1995

NSWCCD Annapolis, MD

Agenda

0800	Welcome (Melville Room)	CAPT Baskerville
0805	Overview	Tim Doyle
0820	Site Tour	CDR Walker
0823	Non-CFC Elimination R&D	Jim Hanrahan
0840	Deep Ocean Vehicle Facility	John Sasse
0855	Propulsion Shaftline Facility	Phil Hatchard
0907	Electrical Power Technology	Howard Stevens Chester Petry
0925	Machinery Acoustic Silencing	Fred Flickinger
0945	Submarine Fluid Dynamics	Dave Larrabee
1000	Magnetics Field Lab	Bruce Hood
1010	Pulsed Power Systems	Tim Doyle
1015	Advanced Electrical Machinery	Mike Superczynski
1035	Wrap-up/Discussion (Deep Ocean Pressure Facility)	Tim Doyle
1100	Joint Spectrum Center	Colonel Flock, USAF
1115	Naval Academy	Dean Shapiro
1125	Community Response (Clipper Center)	
1140	Media Dialogue	
1200	Departure	

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BRAC Site Visit 3-27-1995
Annapolis Detachment
Commissioner Rebecca Cox

Overview

Tim Doyle

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Annapolis Detachment
Commissioner Rebecca Cox

Overview

- Machinery is a Major Contributor to Ship Cost & Mission Capability
- Annapolis Machinery Technologies Improve Fleet Affordability & Sustain Capability

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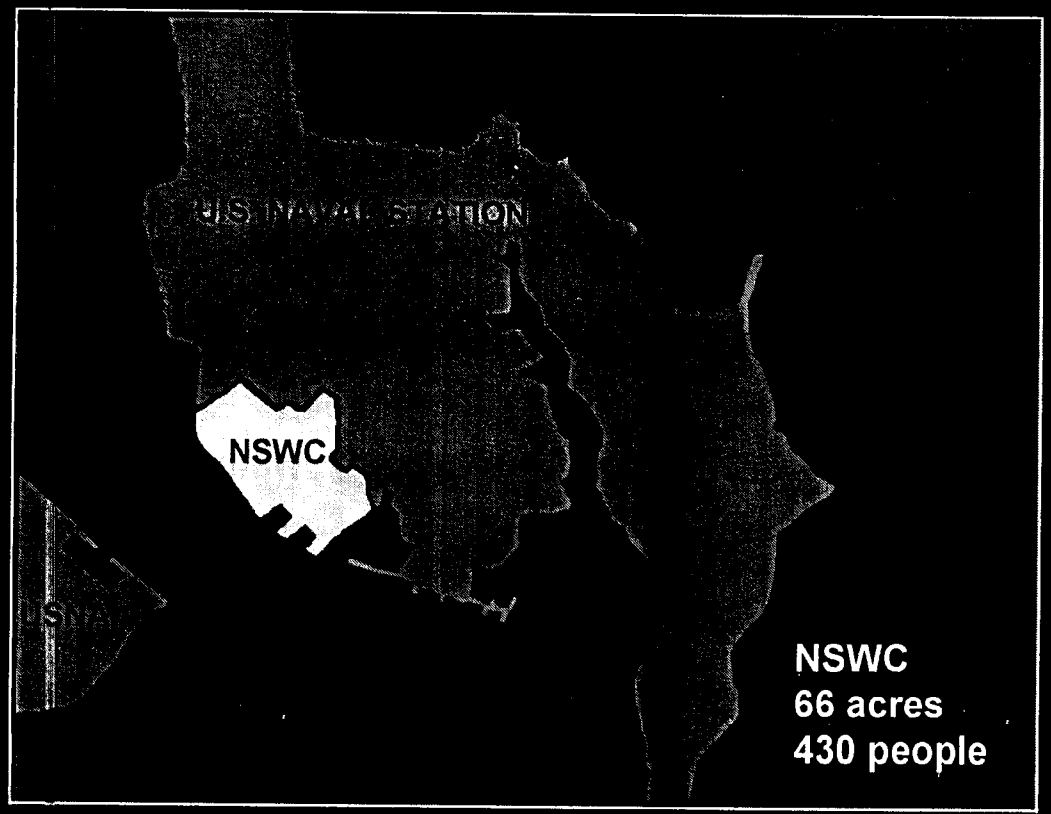
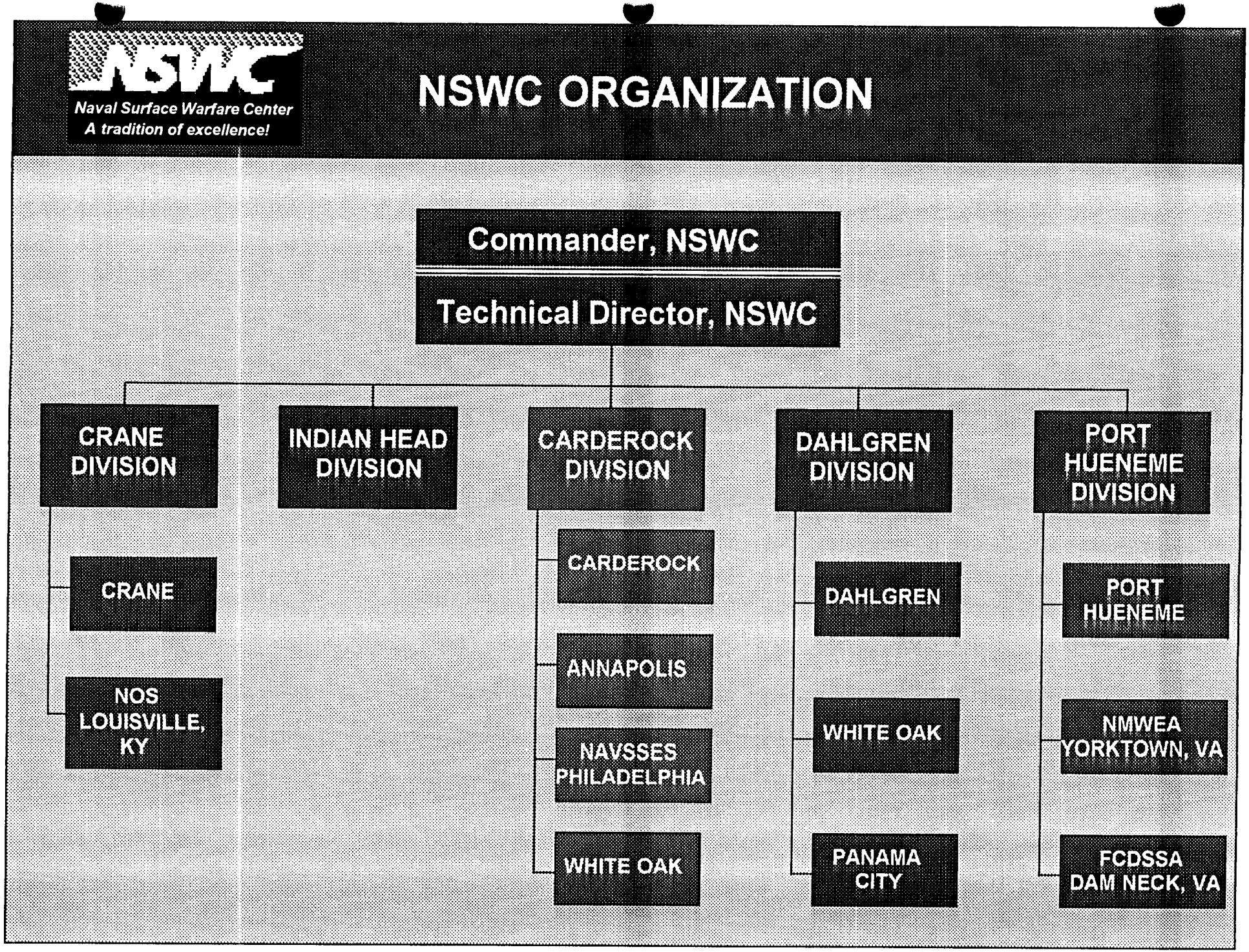
NAVAL SURFACE WARFARE CENTER
CARDEROCK DIV., ANNAPOLIS DET.
ANNAPOLIS, MD

ANNAPOLIS NAVAL COMPLEX

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NSWC ORGANIZATION
Commander, NSWC
Technical Director, NSWC
CRANE DIVISION
INDIAN HEAD DIVISION
CARDEROCK DIVISION
DAHLGREN DIVISION
PORT HUENEME DIVISION
CRANE
NOS LOUISVILLE, KY
CARDEROCK
ANNAPOLIS
NAVSSES PHILADELPHIA
WHITE OAK
DAHLGREN
WHITE OAK
PANAMA CITY
PORT HUENEME
NMWEA YORKTOWN, VA
FCDSSA DAM NECK, VA

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CARDEROCK DIVISION TECHNICAL DIRECTORATES

CODE 10	LOGISTICS AND MACHINERY PROGRAMS
CODE 20	SHIP SYSTEMS AND PROGRAMS
CODE 50	HYDROMECHANICS
CODE 60	SURVIVABILITY, STRUCTURES, AND MATERIALS
CODE 70	SIGNATURES
CODE 80	*MACHINERY RESEARCH AND DEVELOPMENT*
CODE 90	MACHINERY IN-SERVICE ENGINEERING

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MACHINERY R & D DIRECTORATE

- **Mission**

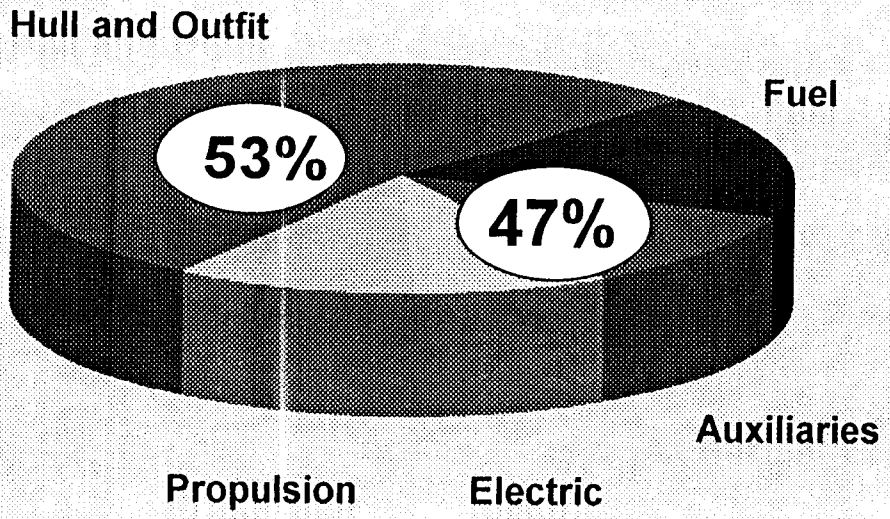
  Perform Research and Development of Naval Shipboard Machinery Including Stealth and Energy Conservation (Annapolis Detachment is the only activity performing this mission)

- **Functions**
  - **Technology & Hardware Development**
  - **System Tradeoffs & Integration**
  - **Specification & Qualification**
  - **Technology Assessments**

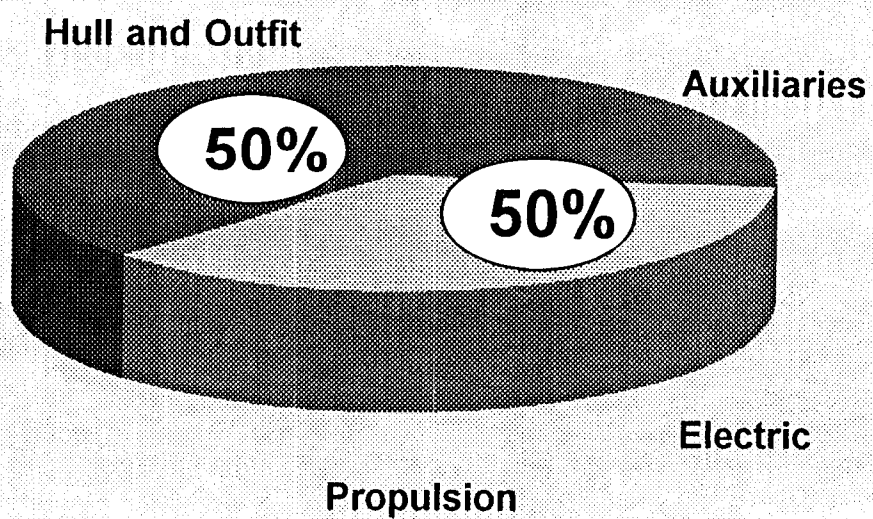
US NAVY SURFACE COMBATANT

(DDG 51, FLT 1 WITHOUT COMBAT SYSTEMS)

SHIP WEIGHT



SHIP BUILDING COST



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MAJOR MACHINERY IMPACTS

- Ship building cost
- Ship operating cost
  - Fuel
  - Crew size and skill level
- Speed and Maneuverability
- Range and Endurance
- Noise, IR, and Magnetic Signatures
- Combat System Operation

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MACHINERY R&D PRODUCTS

Machinery Specialities

Electrical & Mechanical Equipment

Propulsion & Power Generation Systems

Auxiliary Systems

Focus

Affordability
- Procurement & Maintenance
- Manning Reduction
- Fuel Economy

Environmental Compliance
- CFC Substitutes
- Waste Processing
- Emission Controls

Stealth
- Noise
- Magnetic

Safety & Survivability
- Life Support
- Damage Control

Users

Future Ships & Subs

Existing Fleet

U.S. Industry

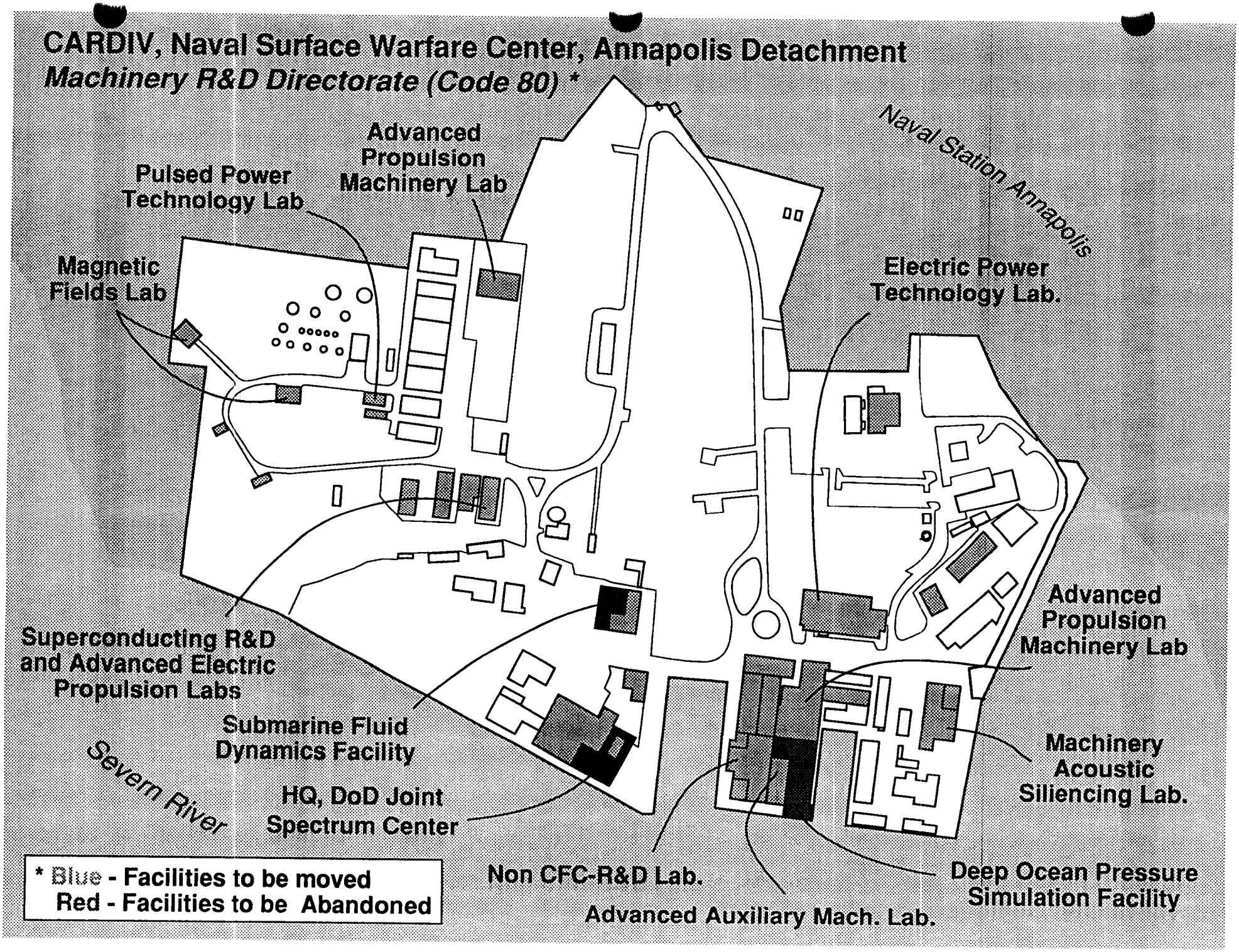
U.S. Maritime

Other DOD

Other Navies

CARDIV, Naval Surface Warfare Center, Annapolis Detachment

*Machinery R&D Directorate (Code 80) **



* Blue - Facilities to be moved
Red - Facilities to be Abandoned

KEY POINTS

- ENVIRONMENTAL COMPLIANCE REQUIRED
  CFC PRODUCTION IS BANNED AFTER 1995
- MISSION CRITICAL COOLING OF COMBAT SYSTEMS
  COMBAT SYSTEMS CANNOT FUNCTION WITHOUT COOLING
  SHIP'S SAFETY IS AT RISK
- ANY DELAY WILL GREATLY RISK DEPLETING THE CFC STOCKPILE
- INDUSTRY IS BEING UTILIZED TO THEIR CAPACITY
  ANNAPOLIS LABORATORY IS THE ONLY FACILITY WITH
  THE CAPACITY AND EXPERTISE TO MEET SCHEDULE
- CFC-114 IS UNIQUE TO NAVY AC PLANTS, COMMERCIAL
  SOLUTIONS DO NOT APPLY

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WHAT IS AN AC PLANT?

- NOT A COMFORT AIR CONDITIONER
- MISSION CRITICAL APPLICATION
  PRODUCES CHILLED WATER FOR COMBAT SYSTEMS:
  i.e., RADAR, SONAR, COMMUNICATIONS,
  WEAPONS FIRE CONTROL COMPUTERS
- NAVY AC PLANTS ARE DIFFERENT THAN COMMERCIAL PLANTS
  UNIQUE ACOUSTIC REQUIREMENTS
  SHOCK AND VIBRATION RESISTANCE
  LIMITED SPACE AVAILABLE ON SHIPS AND SUBMARINES
  SUBMARINE ATMOSPHERIC CONTROL SYSTEM COMPATIBILITY
- NAVY SHIPS USE A DIFFERENT REFRIGERANT THAN INDUSTRY
  INDUSTRY IS BEING UTILIZED, BUT THEY ARE AT CAPACITY

NAVAL COMBATANTS USING CFC-114

- AIRCRAFT CARRIERS
  - USS NIMITZ CLASS
  - USS KITTY HAWK CLASS
  - USS KENNEDY CLASS
  - USS ENTERPRISE CLASS
  - USS INDEPENDENCE CLASS
- SUBMARINES
  - USS OHIO CLASS (TRIDENT)
  - USS LOS ANGELES CLASS
  - USS SEAWOLF CLASS
- DESTROYERS
  - USS ARLEIGH BURKE CLASS
  - USS SPRUANCE CLASS
  - USS KIDD CLASS
- CRUISERS
  - USS TICONDEROGA CLASS
- HELO/LANDING CRAFT CARRIERS
  - USS WASP CLASS
  - USS TARAWA CLASS

TOTAL NUMBER OF AIR CONDITIONING PLANTS: 860
TOTAL FLEET INSTALLED COST: $1.0 BILLION

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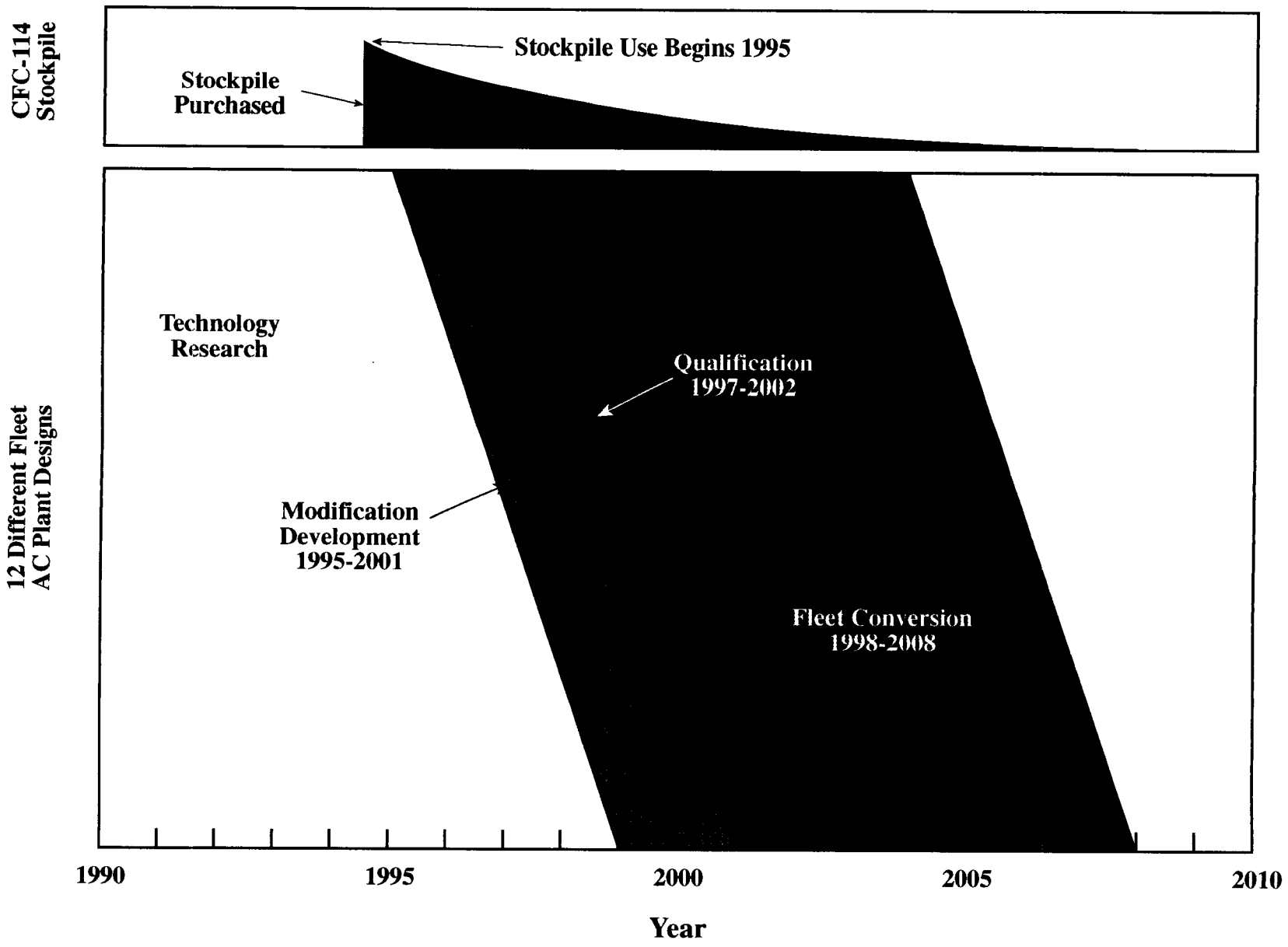
ENVIRONMENTAL COMPLIANCE

- INTERNATIONAL AGREEMENTS TO BAN CFCs i.e., MONTREAL PROTOCOL
- EPA CLEAN AIR ACT REGULATIONS
- PRODUCTION OF ALL CFCs ARE BANNED AFTER 1995
- ORIGINAL REGULATIONS (1989) ONLY CALLED FOR A 50% REDUCTION IN PRODUCTION, THIS RAPID ACCELERATION AND PHASEOUT CAUSED A TIME CRITICAL SCHEDULE.

NAVY UNIQUE REFRIGERANT CFC-114

- COMMERCIALLY CFC-114 IS NOT USED
  NO EQUIVALENT CHEMICAL EXISTS, MODIFICATIONS REQUIRED
  INDUSTRY IS INVOLVED, BUT THEY ARE AT CAPACITY
- SUBMARINE ATMOSPHERIC CONTROL SYSTEM COMPATIBILITY
- POSITIVE PRESSURE REQUIRED TO MINIMIZE MAINTENANCE AND REPAIR PROBLEMS, i.e., IMPROVED READINESS
- ACOUSTIC SILENCING TECHNOLOGY DEVELOPED FOR CFC-114

NON-CFC AIR CONDITIONING SCHEDULE



PROGRAM SCHEDULE IS CRITICAL

- FLEET CONVERSION OF CFC-114 AC PLANTS BEGINS FY 1998.
- DEVELOPMENT AND QUALIFICATION FOR OTHER DESIGNS CONTINUES INTO FY 2002. REMAINING CLASSES WILL BE BACKFIT AS EACH MODIFICATION KIT IS QUALIFIED IN THE ANNAPOLIS FACILITIES.
- CONVERSION OF THE ENTIRE FLEET WILL REQUIRE UNTIL 2008.
- THE NAVY MISSION CRITICAL STOCKPILE OF CFC-114 WAS SIZED FOR THE ABOVE AGGRESSIVE CONVERSION SCHEDULE.
  PRODUCTION OF CFCs ARE BANNED AFTER 1995.
  USE OF THE NAVY STOCKPILE HAS ALREADY BEGUN.
- ANY DELAY WILL GREATLY RISK DEPLETING THE CFC STOCKPILE.
  EXAMPLE:
  1 YEAR DELAY WOULD EFFECT THE FOLLOWING:
  70 SHIPS (268 AC PLANTS) IN 2005
  120 SHIPS (465 AC PLANTS) IN 2006, ETC.
  THESE ARE OUR NEWEST AND MOST CAPABLE SHIPS IN THE FLEET.

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A WORLD CLASS FACILITY

PROVIDING

HYDROSTATIC PRESSURE TESTING SERVICES

TO

GOVERNMENT AGENCIES

AND

PRIVATE INDUSTRY

DEEP OCEAN PRESSURE SIMULATION FACILITY

ANNAPOLIS DETACHMENT
NAVAL SURFACE WARFARE CENTER
ANNAPOLIS, MD

DEEP OCEAN PRESSURE SIMULATION FACILITY

What Is The Purpose Of The Facility:

- Total System Tests in a Controlled Environment at Deep Ocean Conditions
- Testing in Support of Submersible Safety Programs
- Testing to Improve System Reliability and Reduce Cost
- Operated as Cost Center, National Asset, Open to Commercial Use

The *ONLY* facility of its kind in the world:

- World's Largest 12,000 Psi Pressure Vessel
- Simulate Depths of 27,000 Feet
- Horizontal Orientation
- Large Cooling Capacity to Operate Equipment
- Acouctically Quiet

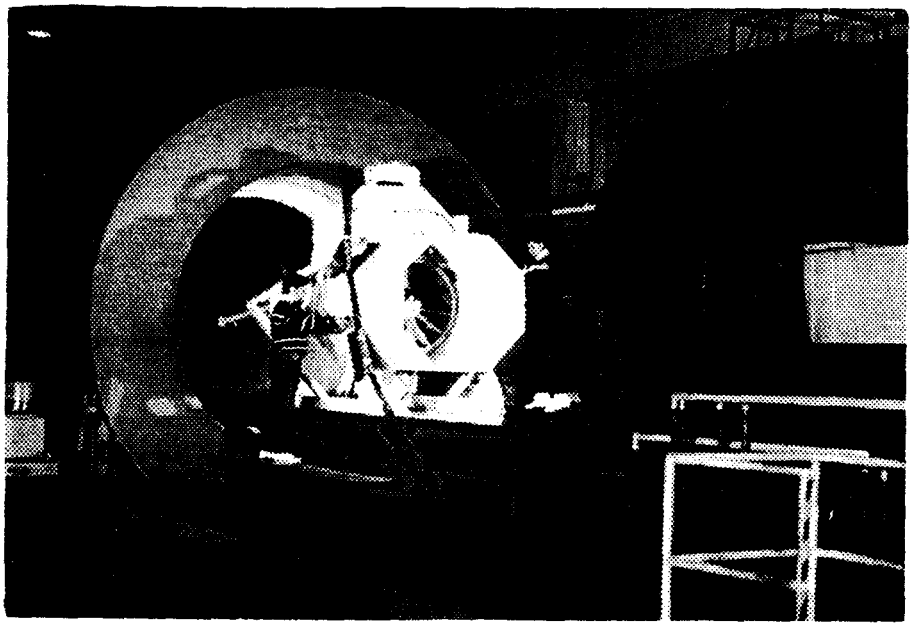
What kinds of tests have been done:

- Manned Submersibles such as ALVIN, PISCES IV, DEEP STAR 2000, etc.
- Unmanned Vehicles such as CURV, DEEP DRONE, SCARAB, etc.
- Submarine SSN 21 Secondary Propulsion Unit
- Navy and Commercial Fiber Optic Cables

What Are The Risks in Closing (Abandoning) This Facility:

- Loss of Facilities for Large Scale Composite Submarine Hull Testing
- Requires Switching to Insitu Testing for Many Systems at Increased Cost
- High Replacement Cost To Reinstitute this Capability

DEEP OCEAN PRESSURE SIMULATION FACILITY



APPLICATION

A national asset, the only facility of its kind in the world, capable of simulating ocean depths to 27,000 feet (12,000 psi) for submersibles and their crew and equipment up to 10 feet in diameter and 27 feet long while oriented in the horizontal position.

IMPORTANCE

This facility represents the most advanced tool available to the Navy to develop large scale composite submarine structures and small undersea manned and unmanned vehicles to meet the Navy undersea missions of surveillance, bottom mapping, search, salvage, recovery and swimmer delivery.

DESCRIPTION

This facility contains four horizontal pressure vessels which use salt or freshwater as the pressurizing fluid. The water temperature can be controlled to a specified temperature within the range from 35°F to 120°F in these vessels. The largest pressure vessel in the world with a static pressure capability of 12,000 psi is the centerpiece of the facility. Its length of 27 feet and diameter of 10 feet are of sufficient size to accommodate full-scale deep ocean vehicles. Numerous manned and unmanned submersibles have made simulated deep test dives in this vessel. Other pressure vessels, ranging in size from 30 inches to 4 feet in diameter, are used to test undersea equipment like submersible electric motors, piping and fittings, electrical connectors, and pressure compensated electrical and electronic equipment.

THE FOLLOWING TYPES OF TESTS WERE PERFORMED IN THE DEEP OCEAN MACHINERY SIMULATION FACILITY WHICH COULD NOT HAVE BEEN PERFORMED ELSEWHERE.

Vehicles

Qualifying and evaluating vehicles such as CURV, ORION, OROV, etc. requires high pressure (10,000 - 12,000 psi), large size (10 ft diameter, 27 ft length) and horizontal orientation.

Deep Ocean Machinery Systems

Qualifying and evaluating deep ocean machinery systems such as the SSN-21 Secondary Propulsion Unit, Deep Submergence Electrical Power Distribution System, etc. requires a horizontal orientation, heat removal capability and large size (10 ft diameter, 27 ft length).

Cable Systems

Evaluation of cable designs such as the Advanced Tethered Vehicle Cable and an assortment of fiber optic cables requires high pressure (10,000 - 12,000 psi), large size (10 ft diameter, 27 ft length) and horizontal orientation.

Materials

Evaluation of composite materials such as ceramic and titanium pressure vessels and ceramic compaction processes requires high pressure (10,000 - 12,000 psi), large size (10 ft diameter, 27 ft length).

Special Testing

Evaluation of sonar aperture and hydrophone array panels requires a low noise hydrostatic pressure environment. Due to its unique fabrication, the tank is inherently acoustically quiet.

Tests Requiring Special Capabilities Of The Large A-Tank Pressure Vessel		
Date	Test	Sponsor
1-89	Ceramic Compaction (size and pressure required A tank)	Coors Ceramics
9-89	ORION Cable (size and pressure required A tank)	Oceaneering
4-90	CURV (size and pressure required A tank)	Oceaneering
6-90 Thru 7-90	Noise Test (test required a quiet vessel)	NSWC Carderock
11-90	ATV Cable (size and pressure required A tank)	NRaD
11-90	Rubber Panels (size requirement and required quiet tank)	NSWC Carderock
10-91	AT&T/ SPAWAR - Special Test (size and pressure required A tank)	U.S. Navy
10-91	Fiber Optic Cable (size and pressure required A tank)	AT&T Bell Labs
11-92	Fiber Optic Cable (size and pressure required A tank)	AT&T Bell Labs
11-92	Westinghouse Ceramic (size, orientation, and pressure required A tank)	Westinghouse
11-92	SSN-21 Secondary Propulsion Unit (size and orientation required A tank)	Westinghouse
1-93	Fiber Optic Cable (size and pressure required A tank)	Simplex
4-93	NCEL Plow Test (orientation required A tank)	NCEL
4-93	SSN-21 Secondary Propulsion Unit (orientation required A tank)	Westinghouse
5-93	DSV Sea Cliff Electrical Distribution (size required A tank, manned submersible components)	Lockheed

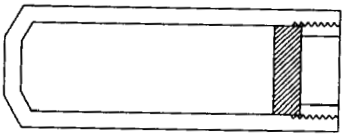
Tests Requiring Special Capabilities Of The Large A-Tank Pressure Vessel		
6-93	Fiber Optic Cable (size and pressure required A tank)	AT&T Bell Labs
8-93	ISMS System (orientation required A tank)	Oceaneering
9-93	AT&T/ SPAWAR (test pressure required A tank)	US Navy
9-93	ISMS System (orientation required A tank)	Oceaneering
10-93	Ceramic Vessel Technology (size and pressure required A tank)	Westinghouse
1-94	Fiber Optic Cable (size and pressure required A tank)	Rochester Cable
5-94	Fiber Optic Cable (size and pressure required A tank)	Rochester Cable
6-94	Fiber Optic Cable (size and pressure required A tank)	AT&T Bell Labs
7-94	Holding Tank (test pressure required A tank)	Westinghouse
1-95	DSV Sea Cliff Manipulators (size required A tank, manned submersible components)	U.S. Navy
3-95	ORION & ORION ROV (size and pressure required A tank)	U.S. Navy

LARGE PRESSURE VESSELS OF THE DEEP OCEAN PRESSURE SIMULATION FACILITY

ANNAPOLIS, MD

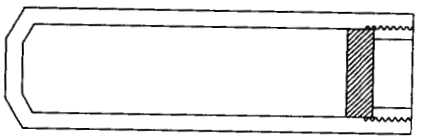
H-TANK PRESSURE VESSEL

DIAMETER = 30 INCHES
USABLE LENGTH = 7 FEET
MAX PRESSURE = 7,000 PSI

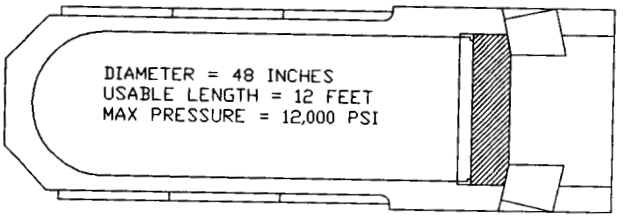


J-TANK PRESSURE VESSEL

DIAMETER = 30 INCHES
USABLE LENGTH = 9 FEET
MAX PRESSURE = 10,000 PSI

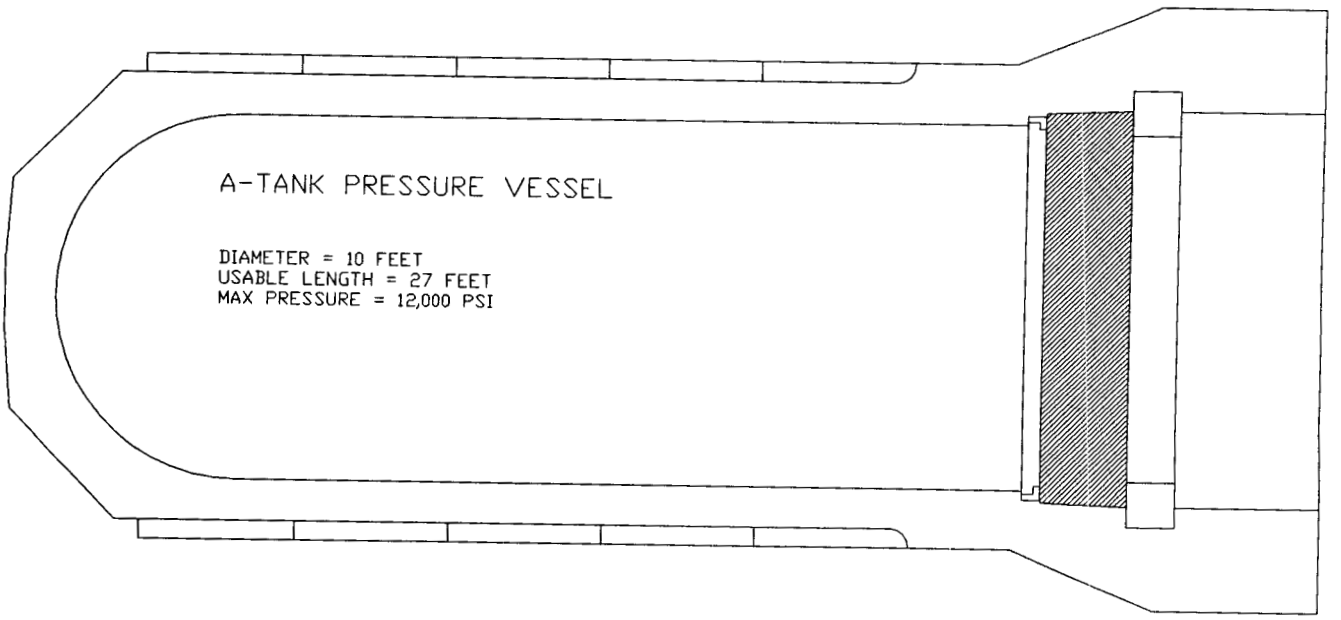


B-TANK PRESSURE VESSEL



A-TANK PRESSURE VESSEL

DIAMETER = 10 FEET
USABLE LENGTH = 27 FEET
MAX PRESSURE = 12,000 PSI



HOW TO CONDUCT BUSINESS WITH THE

NAVAL SURFACE WARFARE CENTER

GENERAL: The Deep Ocean Pressure Simulation Facility is a unique national asset for the purpose of conducting hydrostatic pressure tests for the Navy, other government agencies and private industry.

The facility is operated as a "cost center" . This means the customer will be charged the actual labor and material cost to setup and operate their test plus a usage fee for the pressure vessel to be set aside for the maintenance and upkeep of the facility.

FIRST STEP: Contact the Deep Ocean Pressure Simulation Facility at the Naval Surface Warfare Center in Annapolis, MD by phone at 410-267-2844 (FAX 410-267-3866) or write to: Officer in Charge, Annapolis Detachment, Carderock Division, Naval Surface Warfare Center, Attention: Code 8520, 3A Leggett Circle, Annapolis, MD 21402-5067. Give the Facility your test requirements so that a cost estimate can be generated.

DEPARTMENT OF DEFENSE: In preparation for testing, the DoD customer should forward their Work Request or Military Interagency Purchase Request to the Center at the above address so an account can be setup for this work. Once the account and job order number have been arranged, work can begin.

GOVERNMENT AGENCIES: Other government agencies should send their work authorization and financial documents to the Center at the above address so an account can be setup for this work. Once the account and job order number have been arranged, work can begin. A surcharge of 2.1% will be assessed all non-DoD Federal customers.

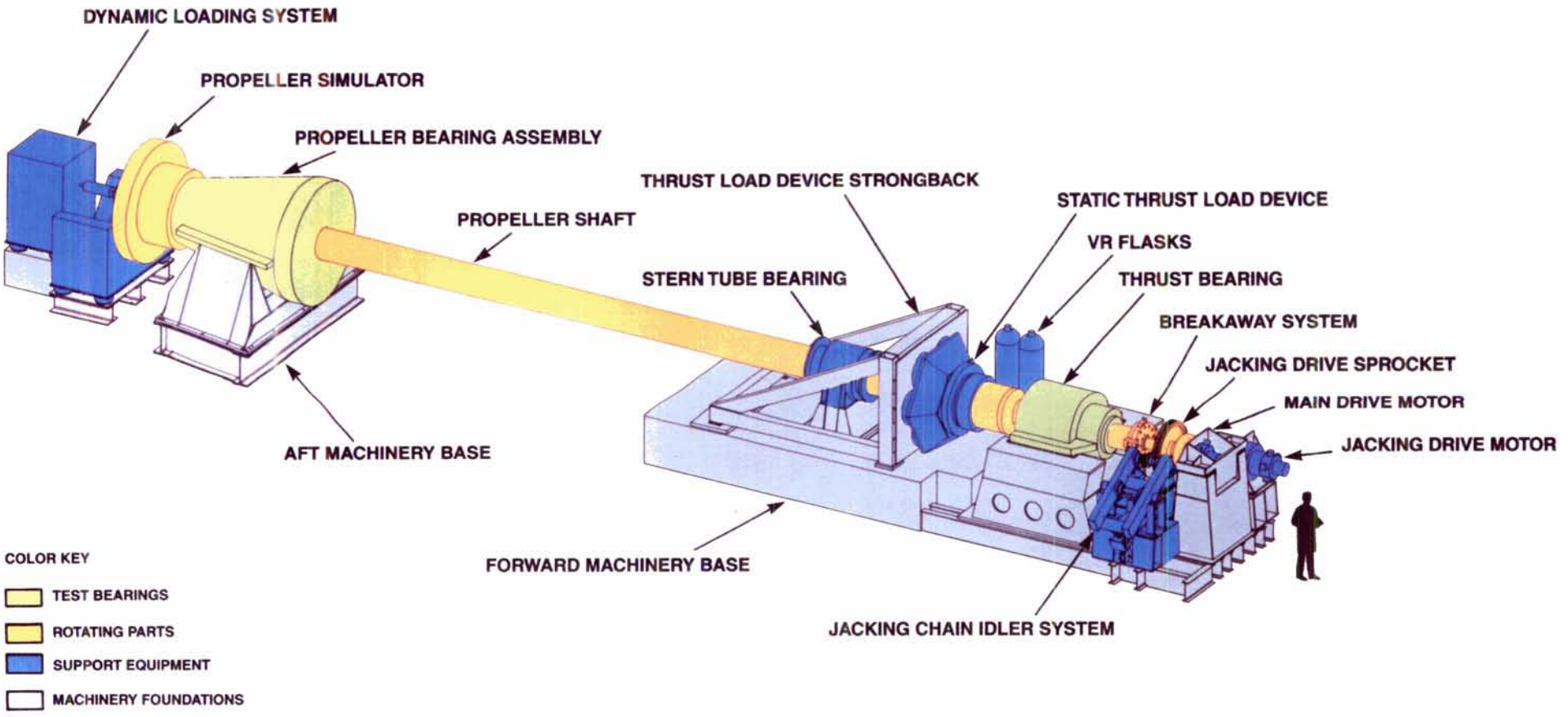
PRIVATE INDUSTRY: Work for private industry customers will be undertaken on a cost-reimbursement type contract. Private parties should forward their authorization specifying the scope of work to be performed along with their check in the amount of the initial cost estimate so an account and job order number can be arranged.

Under a cost-reimbursement type contract the cost including labor, material, and usage fee will be charged against your initial deposit as the services are performed. If the scope of work increases during the test program, the customer will be asked to deposit funds to cover the revised estimate. In the event that the actual cost is less than the funds deposited, the balance will be refunded at the time the program is considered complete.

Before work can be undertake for any private organization, a signed original of a standard indemnity agreement must be received from the customer indemnifying the Government from suits or actions that may arise from damage to the customers property as a result of testing.

Private parties will be charged a 3.7% surcharge. However, if the customer's work pertains to a DoD cost-reimbursement type contract the surcharge will be waived if the contract number is specified.

SHAFTLINE COMPONENT DEVELOPMENT FACILITY



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NAVAL SURFACE WARFARE CENTER
ANNAPOLIS DETACHMENT

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SHAFTLINE COMPONENT DEVELOPMENT FACILITY

OBJECTIVE

DEVELOPMENT AND QUALIFICATION TESTING

OF SUBMARINE PROPELLER SHAFTLINE COMPONENTS

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SHAFTLINE COMPONENT DEVELOPMENT FACILITY

APPROACH

DUPLICATE ATTACK SUBMARINE DRIVE TRAIN FROM THRUST BEARING TO PROPELLER LOCATION

UTILIZE MASSIVE FLOOR TO ACOUSTICALLY ISOLATE COMPONENTS FROM EACH OTHER

SIMULATE CONSTANT AND VIBRATIONAL LOADS USING EXTERNAL DEVICES

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SHAFTLINE COMPONENT DEVELOPMENT FACILITY

BACKGROUND

SUBMARINES HAVE ONE MAIN PROPULSION SHAFT

COMPONENTS AND SYSTEMS ALONG THE SHAFT MUST BE HIGHLY RELIABLE FOR SHIP AND CREW SAFETY

LAND BASED DEVELOPMENT AND QUALIFICATION REQUIRED TO OVERSTRESS NEW COMPONENTS WITHOUT EXPOSING CREW TO HIGH RISK

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SHAFTLINE COMPONENT DEVELOPMENT FACILITY

CDNSWC ANNAPOLIS CONTRIBUTION

TECHNICAL TEAM EXPERIENCED IN ALL VITAL AREAS

- THRUST BEARING QUALIFICATION
- THRUST BEARING COMPONENT DEVELOPMENT
- MACHINERY VIBRATION
- VIBRATION REDUCER DEVELOPMENT
- SHAFT AND COUPLING DESIGN
- WATERBORNE BEARING DEVELOPMENT
- ACOUSTIC DESIGN OF FACILITIES

COST EFFECTIVE SOLUTION VERSUS HAVING THE FACILITY CONSTRUCTED AT A VENDOR'S SITE

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SHAFTLINE COMPONENT DEVELOPMENT FACILITY

PAYOFF

SYSTEM DESIGN IS REFINED WITHOUT ENDANGERING SHIP OR CREW

NAVY OBTAINS INDEPENDENT VERIFICATION OF VENDOR PERFORMANCE

FACILITY REMAINS AS NAVY ASSET FOR FUTURE USE

NAVY COMPOSITE PROPULSION SHAFTING PROGRAM

OBJECTIVE

DEVELOP THE TECHNOLOGY BASE REQUIRED TO DESIGN, MANUFACTURE, AND QUALIFY ADVANCED COMPOSITE PROPULSION SHAFTING FOR SURFACE SHIPS AND SUBMARINES

BENEFITS

ADVANCED COMPOSITES OFFER THE POTENTIAL TO IMPROVE NAVY PROPULSION SHAFTING BY

- REDUCING GENERAL AND GALVANIC CORROSION EFFECTS
- INCREASING PAYLOAD AND STABILITY DUE TO SIGNIFICANT WEIGHT SAVINGS
- INCREASING ALLOWABLE FATIGUE STRESSES IN THE SEA WATER ENVIRONMENT
- OPTIMIZING SHIP SHAFT-LINE DESIGN PARAMETERS BY TAILORING COMPOSITE PROPERTIES TO MEET PERFORMANCE REQUIREMENTS
- DECREASING U.S. RELIANCE ON STRATEGIC MATERIALS
- REDUCING SHIP SIGNATURES THUS DETECTABILITY
- REDUCING ACQUISITION AND LIFE CYCLE COSTS
- IMPROVING AVAILABILITY THROUGH AUTOMATION AND STANDARDIZATION

APPROACH

CHARACTERIZE MATERIAL PROPERTIES, EVALUATE THE PERFORMANCE LIMITS, AND VERIFY THE DESIGN OF ANALYTICALLY-OPTIMIZED COMPOSITE LAMINATES, TITANIUM EXTRUSIONS, AND JOINING SYSTEMS VIA SMALL-SCALE LABORATORY INVESTIGATIONS, FULL-SCALE LAND-BASED TESTING, AND AT-SEA DEMONSTRATIONS.

NAVY COMPOSITE PROPULSION SHAFTING PROGRAM

CDNSWC DET. ANNAPOLIS CONTRIBUTIONS:

- CDNSWC ORIGINATED THE NAVY'S COMPOSITE PROPULSION SHAFT PROGRAM AND ANNAPOLIS DETACHMENT ENGINEERS DEVELOPED PATENT RIGHTS ON LAMINATED SHAFT CONSTRUCTION FOR THE NAVY (NOTICE OF ALLOWABILITY GRANTED 8/14/93).

- ANNAPOLIS DETACHMENT PERSONNEL HAVE DESIGNED, SPECIFIED, FABRICATED AND EVALUATED THE FOLLOWING COMPOSITE PROPULSION SHAFT SYSTEMS FOR THE NAVY:

  - 335 HP, 900 RPM, 2 1/2" DIA. COMPOSITE PROPULSION SHAFT 26 FOOT LONG

  - 275 HP, 900 RPM, 2 1/2" DIA. COMPOSITE PROPULSION SHAFT 23 FOOT LONG

  - 50,000 HP, 150 RPM, 33" DIA. COMPOSITE PROPULSION SHAFT 11 FOOT LONG

- THE CURRENT COMPOSITE PROPULSION SHAFT PROGRAM IS A MULTI MILLION DOLLAR PER YEAR ~~PROGRAM~~ DOD INVESTMENT AND THE NAVY IS DEPENDING UPON THE ANNAPOLIS DETACHMENT TO:

  - DESIGN, FABRICATE, & OPERATE UNIQUE FACILITIES TO CONDUCT MECHANICAL EVALUATIONS

  - DEVELOP MECHANICAL PROPERTY DATABASE FOR THE COMPOSITE SHAFT MATERIAL SYSTEM "BASE LAMINATE".

  - DEFINE TECHNICAL PROBLEMS, DEVELOP SOLUTIONS, AND IMPLEMENT INVESTIGATIONS TO RESOLVE MARINE TECHNICAL ISSUES RELATED TO THE COMPOSITE PROPULSION SHAFT PROGRAM.

- IN 1995 THE ANNAPOLIS DETACHMENT WILL INITIATE AN EXTENSIVE YEAR LONG EVALUATION OF A COMPOSITE/TITANIUM JOINT DESIGN. THE RESULTS WILL HELP VALIDATE ANALYTICAL MODELS GENERATED BY THE DESIGN AGENT. THE FULL-SCALE JOINT DESIGN IS BASED ON PREVIOUS DEVELOPMENTS AT THE ANNAPOLIS DETACHMENT WITH SMALL-SCALE MODELS.

- IN 1997 THE ANNAPOLIS DETACHMENT WILL INITIATE A TWO YEAR EVALUATION OF A 60 FOOT LONG, FULL-SCALE COMPOSITE PROPULSION SHAFT IN A LAND BASED TEST FACILITY (LBTF) PRIOR TO SHIPBOARD INSTALLATION SCHEDULED IN 1999.

COMMERCIAL/MARINE STANDARD FAMILY OF COMPOSITE PUMPS

FLEET PROBLEMS

Proliferation of 7,588 different pump configuration created serious problems in: supply, support, technical documentation, training, and maintenance

High shipboard **Failure Rates** caused by corrosion, erosion, galvanic imcompatibility, and pitting under stagnant conditions

SOLUTIONS

Standardize a family of close-coupled, centrifugal pumps that will maximize the commonality of parts between pumps and facilitate the dual use of standard commercial or militarized motors as service conditions demand

Construct the standard pumps of **Advanced Composite Materials** that eliminate corrosion and galvanic effects while reducing weight, cost, and magnetic signatures

PAYOFFS

Affordabilty through:

- One basic Navy owned design for all pumps in the standard family
- Maximum interchangeability of components between pump sizes
- Minimum number of family components
- Improved pump performance/reliability
- Maintenance savings
- Improved logistics support
- Stopping the proliferation of APLs and NSNs

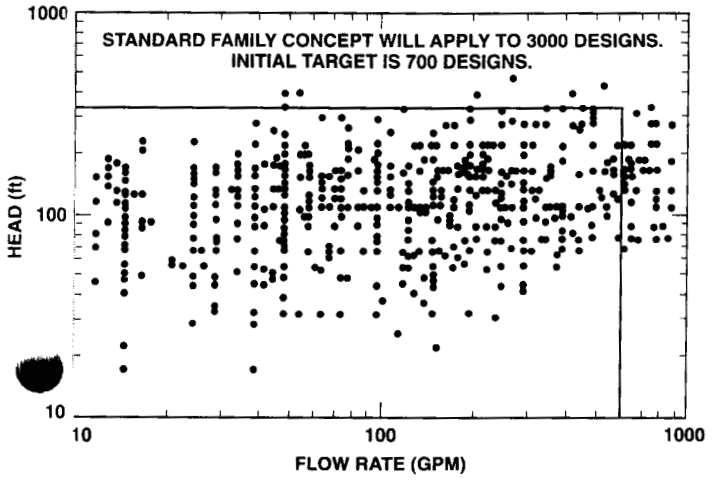
20X24

"We absolutely cannot afford to continue to introduce large numbers of unique components into the Navy or the commercial sector. The infrastructure cost will kill us."

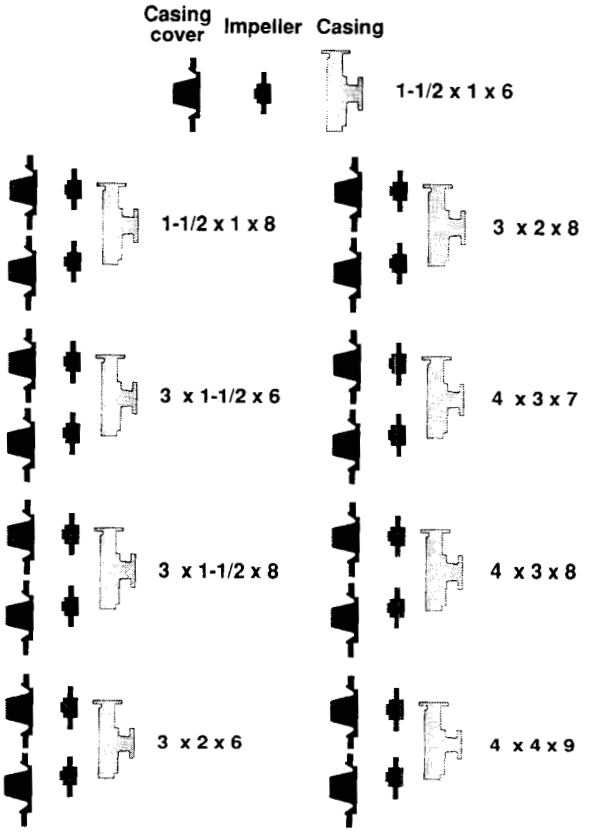
Vice Admiral Kenneth Malley, USN
1992 ASNE Day Presidents Club
Luncheon Address

SURFACE COMBATANT CENTRIFUGAL PUMP DISTRIBUTION

All Major Services



STANDARD FAMILY COMPOSITE CENTRIFUGAL PUMPS



Family of 9 Sizes Replaces 700 Designs

END RESULT:

- **$1.7M annual savings in logistic support**
- **$8.0M annual savings on acquisition cost**

"We absolutely cannot afford to continue to introduce large numbers of unique components into the Navy or the commercial sector. The infrastructure cost will kill us."

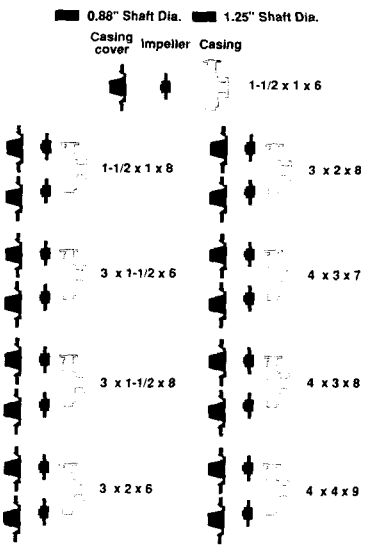
Vice Admiral Kenneth Malley, USN
1992 ASNE Day Presidents Club
Luncheon Address

FAMILY COMPONENTS

Casings	9
Impellers	17
Casing Covers	17
Motor Support Castings	5
Motor Support Machinings	15
Impeller Nuts	2
Impeller Studs	2
Shaft Sleeves	2
Box Bushings	2
Drain/Vent Plug	1
Casing Rings	8
Wear Rings	2
Mechanical Seals	2

79 Replacement Parts Vice Current Inventory 11,152

STANDARD FAMILY COMPOSITE CENTRIFUGAL PUMPS



CDNSWC DET., ANNAPOLIS CONTRIBUTIONS

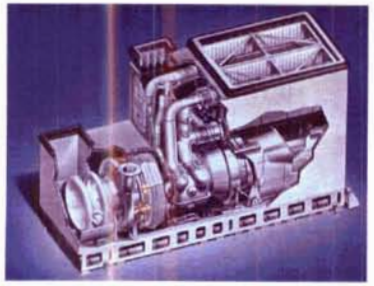
The Annapolis Detachment has served as the Navy's chosen technical agent in the development of the family of composite material pumps. Taking advantage of the expertise in machinery, materials, testing, and analytical methods located in Annapolis, the Detachment has been an independent, and unbiased resource for the Navy which has:

- Defined the problems and solutions related to centrifugal pumps through surveys of shipboard and composite pumps
- Evaluated commercial composite pumps to quantify their performance as related to Navy requirements
- Developed the specifications and requirements for a composite pump design that meets Navy needs and is suitable for use in the commercial market
- Awarded and administered a contract with a major pump manufacturer for the design of the standard pump family, and the manufacture and test of prototype pumps

Current plans call for the Detachment to continue in it's roll in administering the contract for the development of the Commercial/Marine Standard Family Composite Pumps through completion of the contract in FY 96. Additionally the Detachment is to serve as the Test Director for the Technical Evaluation of the prototype pumps and will prepare the final report for this effort.

ADVANCED SURFACE MACHINERY PROGRAMS

Intercooled Recuperated Gas Turbine



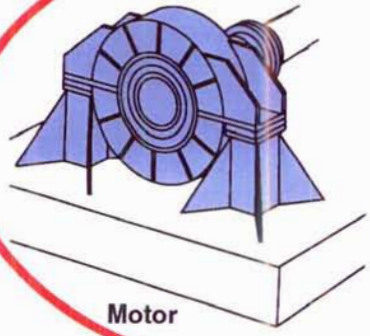
Standard Monitoring and Control System

Console

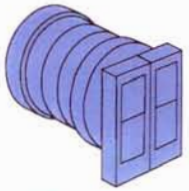
Control and Collection Unit

Mini-Remote Terminal Unit

Electric Propulsion

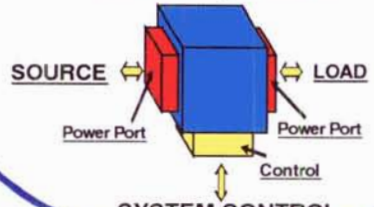


Motor

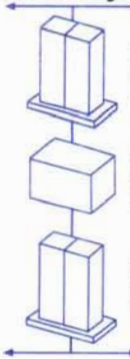


Generator

Power Electronic Building Block



Zonal Electrical Distribution System

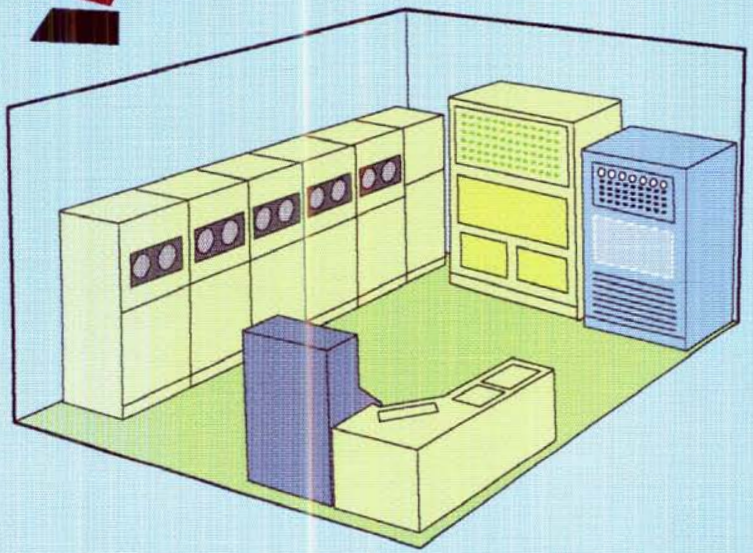


Ship Service Converter Module (SSCM)

Ship Service Inverter Module (SSIM)

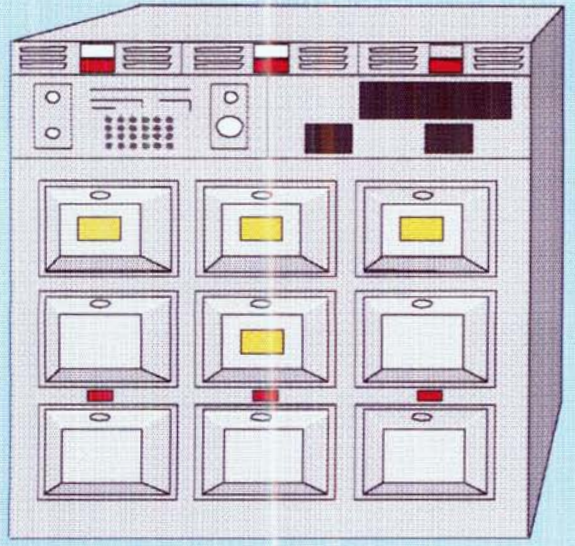
Ship Service Converter Module (SSCM)

The "First Electronic Revolution"



- Transistors
- Integrated Circuits
- The Information Age

The "Second Electronic Revolution"



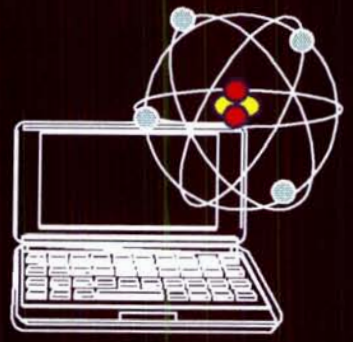
- *MOS Controlled Thyristor*
- *Power Electronic Building Blocks*
- *The Electric Age*

PEBB

In forty years the combined improvement in computers equals 30 orders of magnitude
(based on size, mass storage, reliability, cost, power consumption and processing speed).

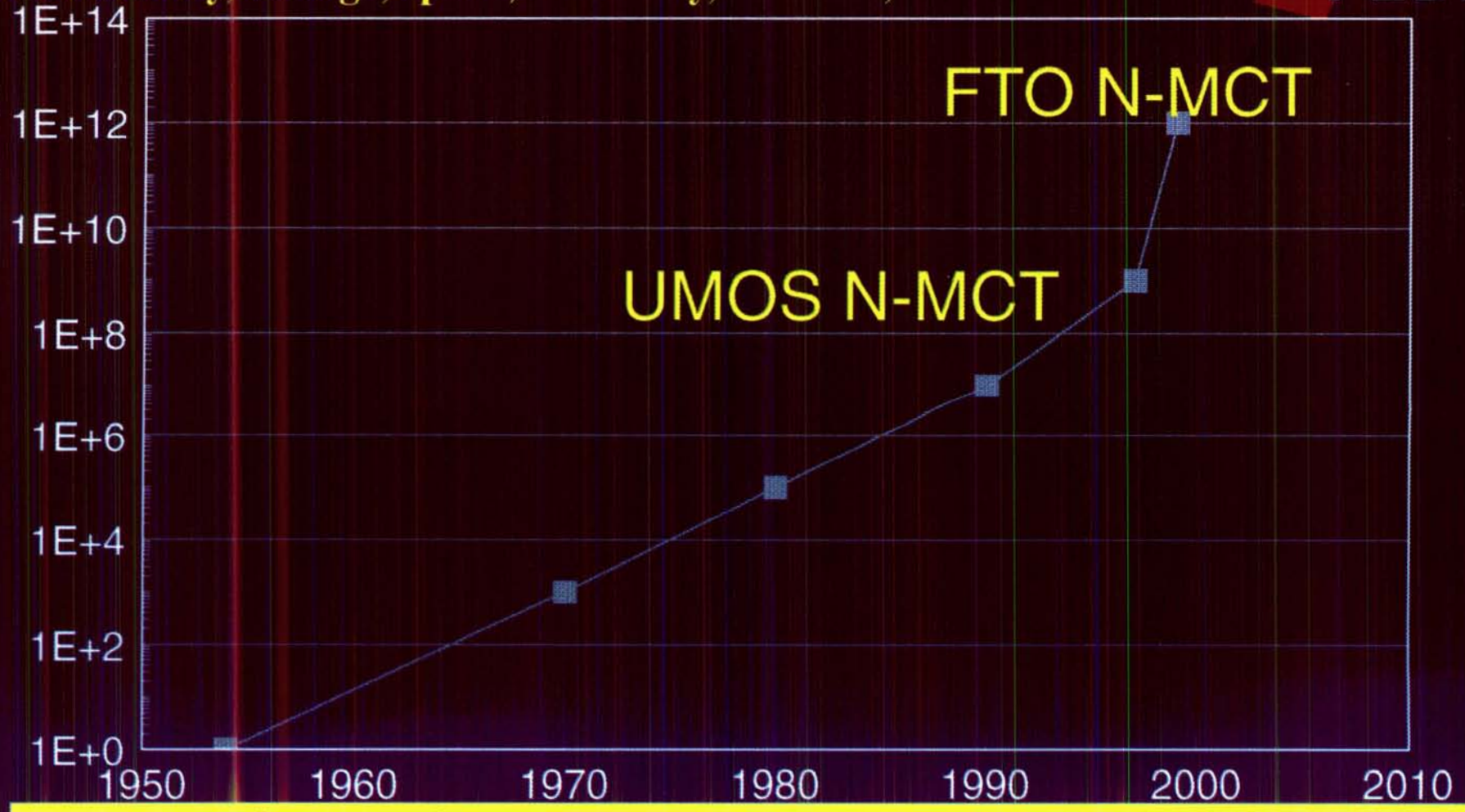
The Milky Way galaxy diameter is about 30 orders of magnitude greater than that of an atom...

David W. Mahle
The Virtual Corporation



Power Semiconductor Device Improvement

(current density, voltage, speed, reliability, and cost)



7 orders of magnitude over the last 40 years

5 orders of magnitude over the next 5 years

Market

- Market Size
  - Power Semiconductors $3B/year
  - System Application $300B/year
  - System Application (2000) $1T/year
- Market Share
  - Japan 45% (rising)
  - US 10% (falling)
- PEBB market = $0.3-1T of the Year 2000 System Market

COMMERCIAL APPLICATIONS OF POWER ELECTRONIC BUILDING BLOCKS

UTILITIES:

- HIGH VOLTAGE DC DISTRIBUTION
- DC/AC POWER CONVERSION
- POWER FACTOR CONTROL ELECTRONICS

INDUSTRIAL:

- INDUCTION MOTOR DRIVES
- AIR CONDITIONING & HEATING
- ELEVATOR DRIVES
- EXCAVATOR DRIVES
- PAPER MILL DRIVES
- COMPUTER POWER SUPPLIES

TRANSPORTATION:

- LOCOMOTIVES
- TRANSIT CARS
- ELECTRIC AUTOS
- GOLF CARTS

AEROSPACE:

- AIRPLANES
- SATELLITES

ALTERNATE ENERGY SOURCES:

- WIND MILLS
- SOLAR PANELS
- FUEL CELL PLANTS

DUAL USE TECHNOLOGY

NAVY PEBB APPLICATIONS

POWER SUPPLIES & AMPLIFIERS:

ADVANCED DC DISTRIBUTION*

INTEGRATED POWER CONVERSION CENTER*

- SONAR, RADAR, COMPUTERS
- OXYGEN GENERATORS
- FREQUENCY CHANGERS
- INVERTERS

VERY HIGH POWER ELECTRONICS:

ELECTRIC DRIVE FOR SHIPS & SUBS*

PROPULSION DERIVED SHIP SERVICE*

- HIGH ENERGY PULSE POWER*
- ELECTROMAGNETIC LAUNCH*

SWITCHGEAR:

- INTEGRATED ELECTRICAL DISTRIBUTION
- INTEGRATED MONITORING & CONTROL

CONTROLLERS & MOTOR DRIVES:

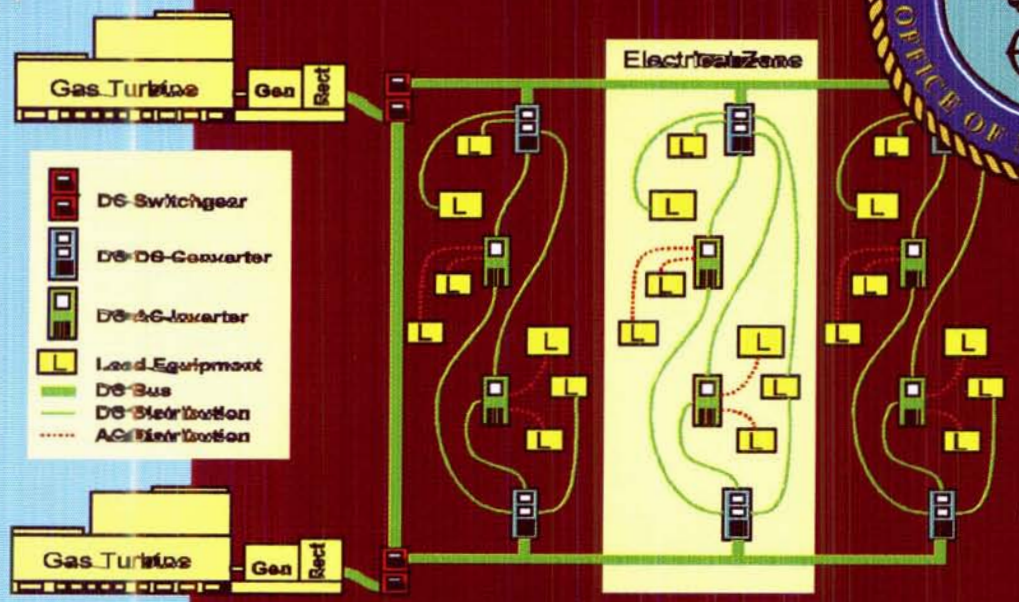
ACTUATORS*

VARIABLE FLOW HYDRAULICS*

- AUXILIARIES -- DISTRIBUTED/ SMART*
- ALL MOTORS -- REDUCED IN-RUSH CURRENT
- AIR CONDITIONING
- TRIM & DRAIN
- SEA WATER & FRESH WATER COOLING
- TORPEDOES
- MAGNETIC BEARINGS

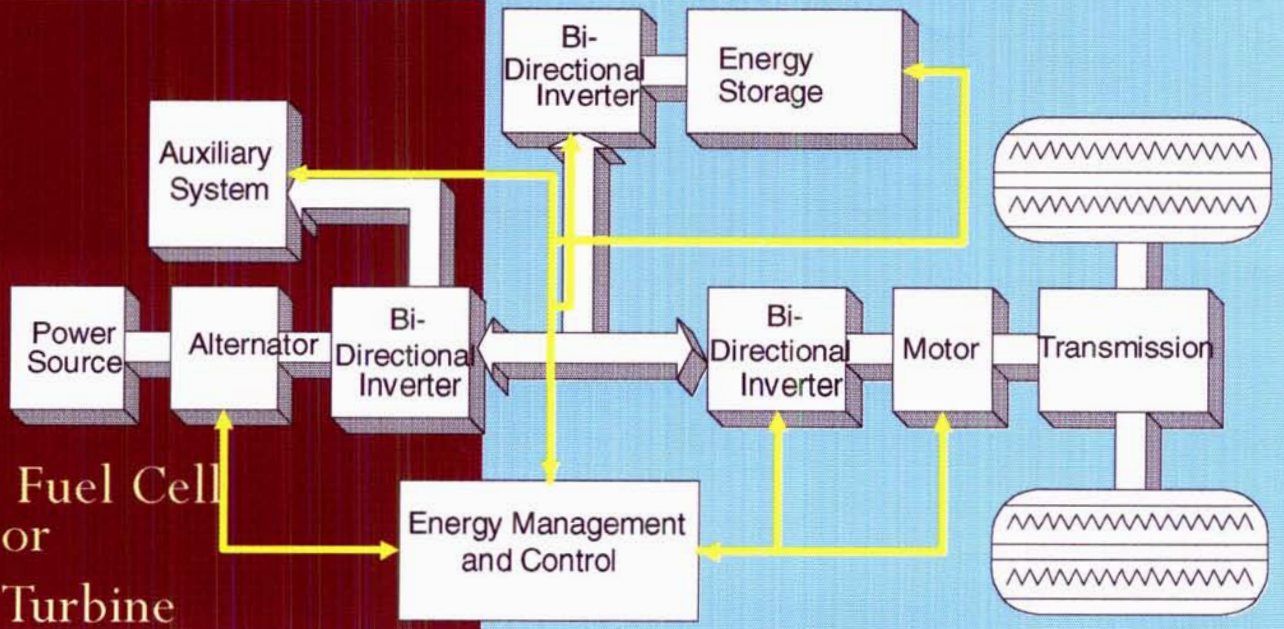
***FUTURE SURFACE SHIP & SUBMARINE APPLICATIONS**

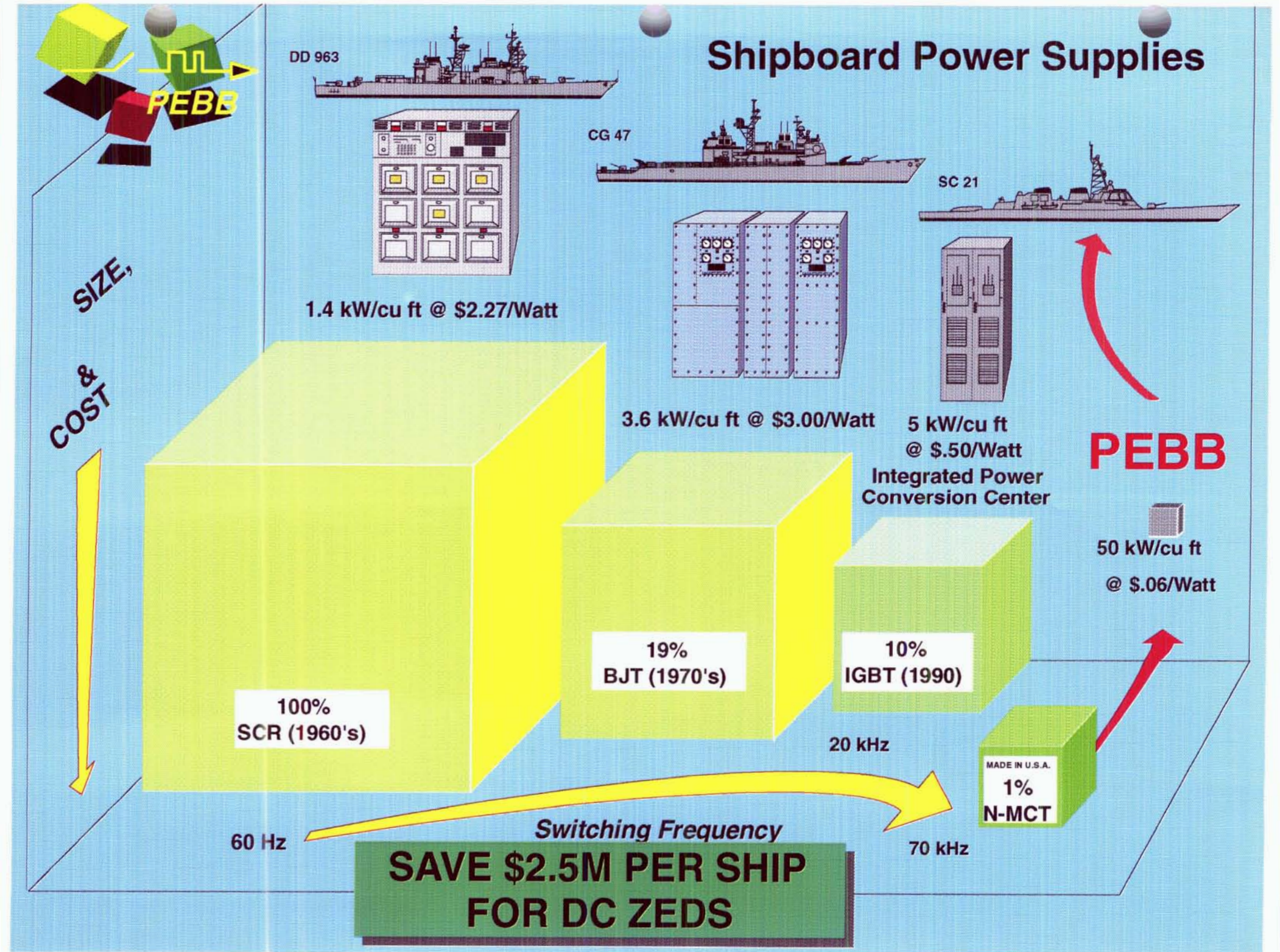
PEBB



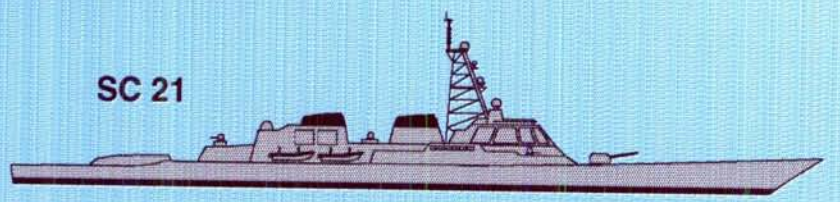
- Advanced Shipboard Machinery
- Integrated Power System
- DC Zonal Electrical Distribution System

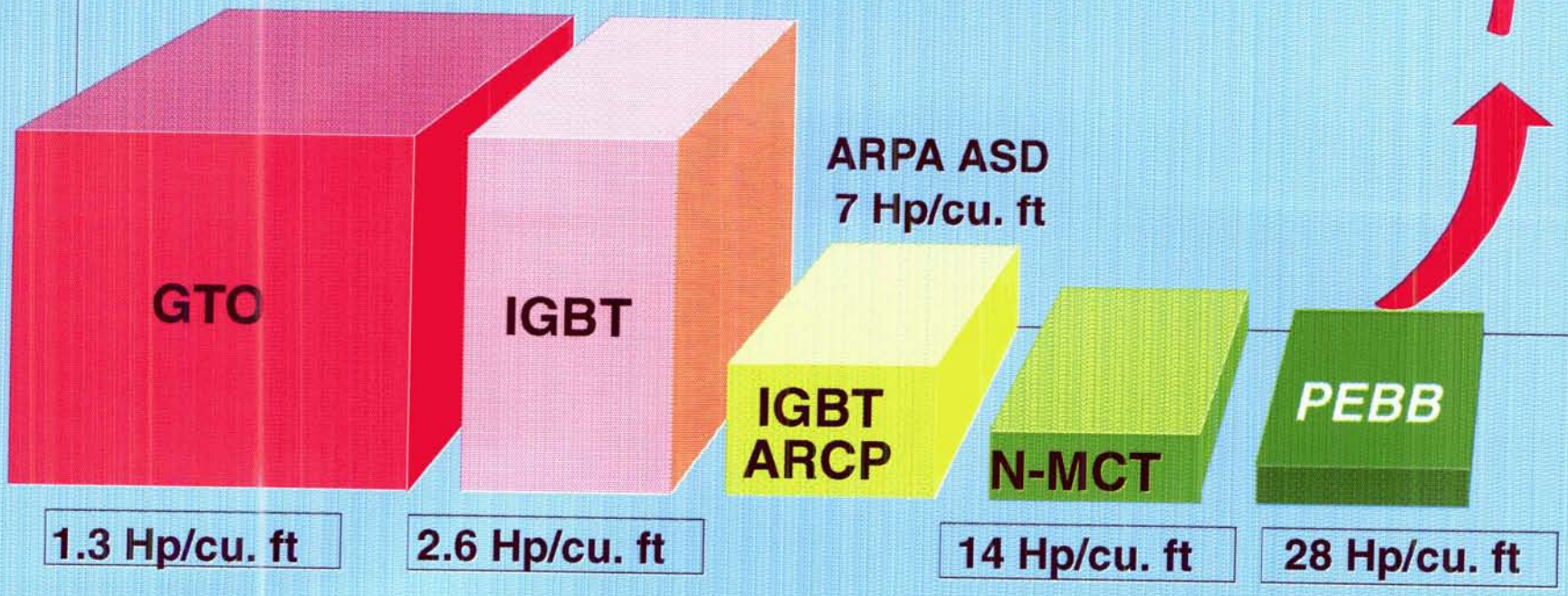
- Partnership for a New Generation Vehicle - DOE
- Fly by Light, Power by Wire - Air Force & NASA
- Electric Tank - Army




PEBB
Shipboard Power Supplies
DD 963
CG 47
SC 21
1.4 kW/cu ft @ $2.27/Watt
3.6 kW/cu ft @ $3.00/Watt
5 kW/cu ft
@ $.50/Watt
Integrated Power
Conversion Center
PEBB
50 kW/cu ft
@ $.06/Watt
SIZE,
&
COST
100%
SCR (1960's)
19%
BJT (1970's)
10%
IGBT (1990)
20 kHz
MADE IN U.S.A.
1%
N-MCT
60 Hz
Switching Frequency
70 kHz
SAVE $2.5M PER SHIP
FOR DC ZEDS

Navy Adjustable Speed Drives





60 Hz → Switching Frequency → 70 KHz

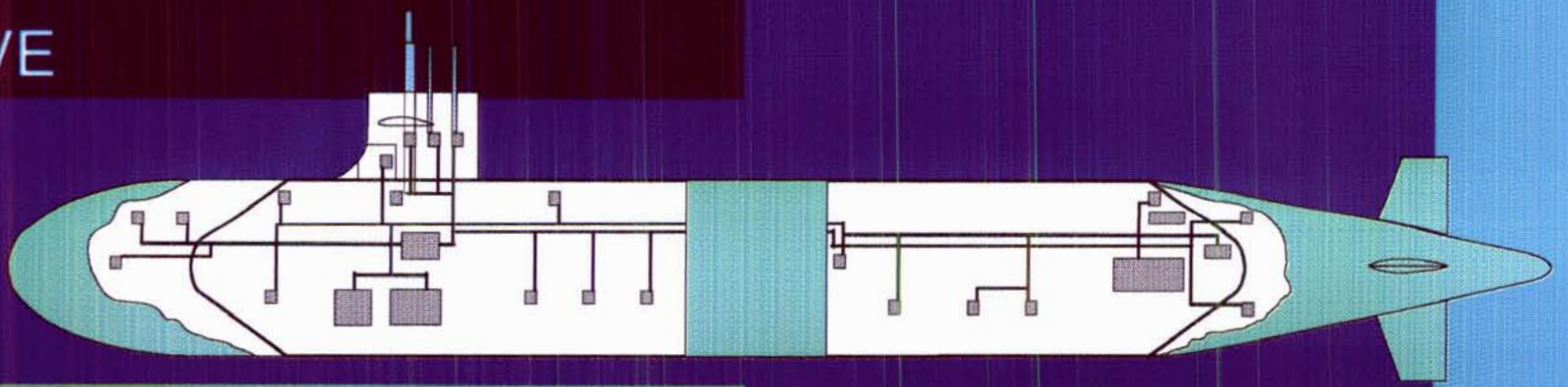
SAVE $2.6M PER SHIP FOR IPS

DISTRIBUTED ACTUATION SYSTEM

PEBB

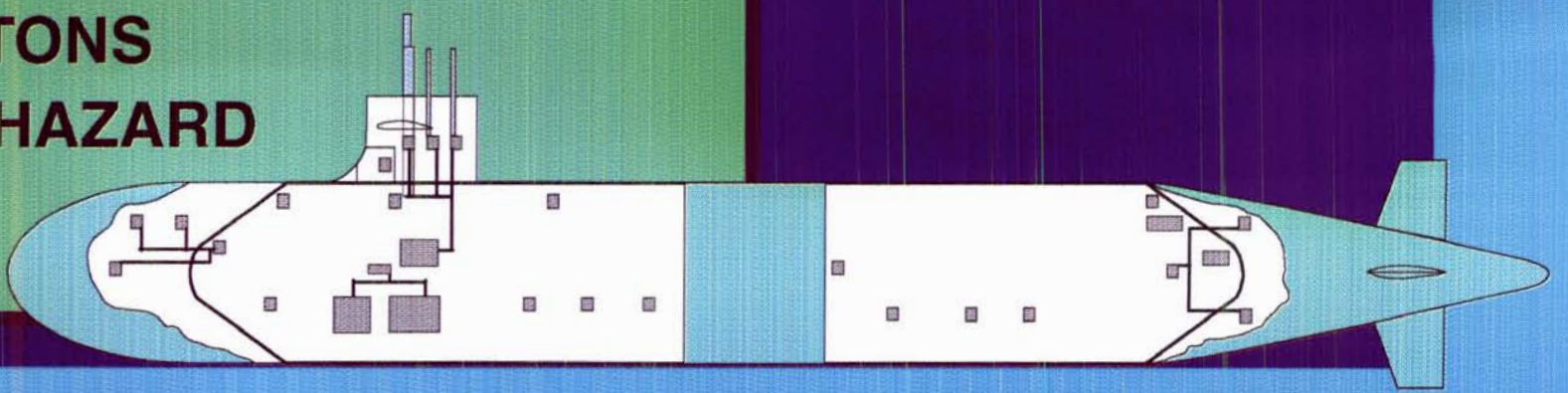
CENTRALIZED HYDRAULIC:

- HEAVY
- EXPENSIVE

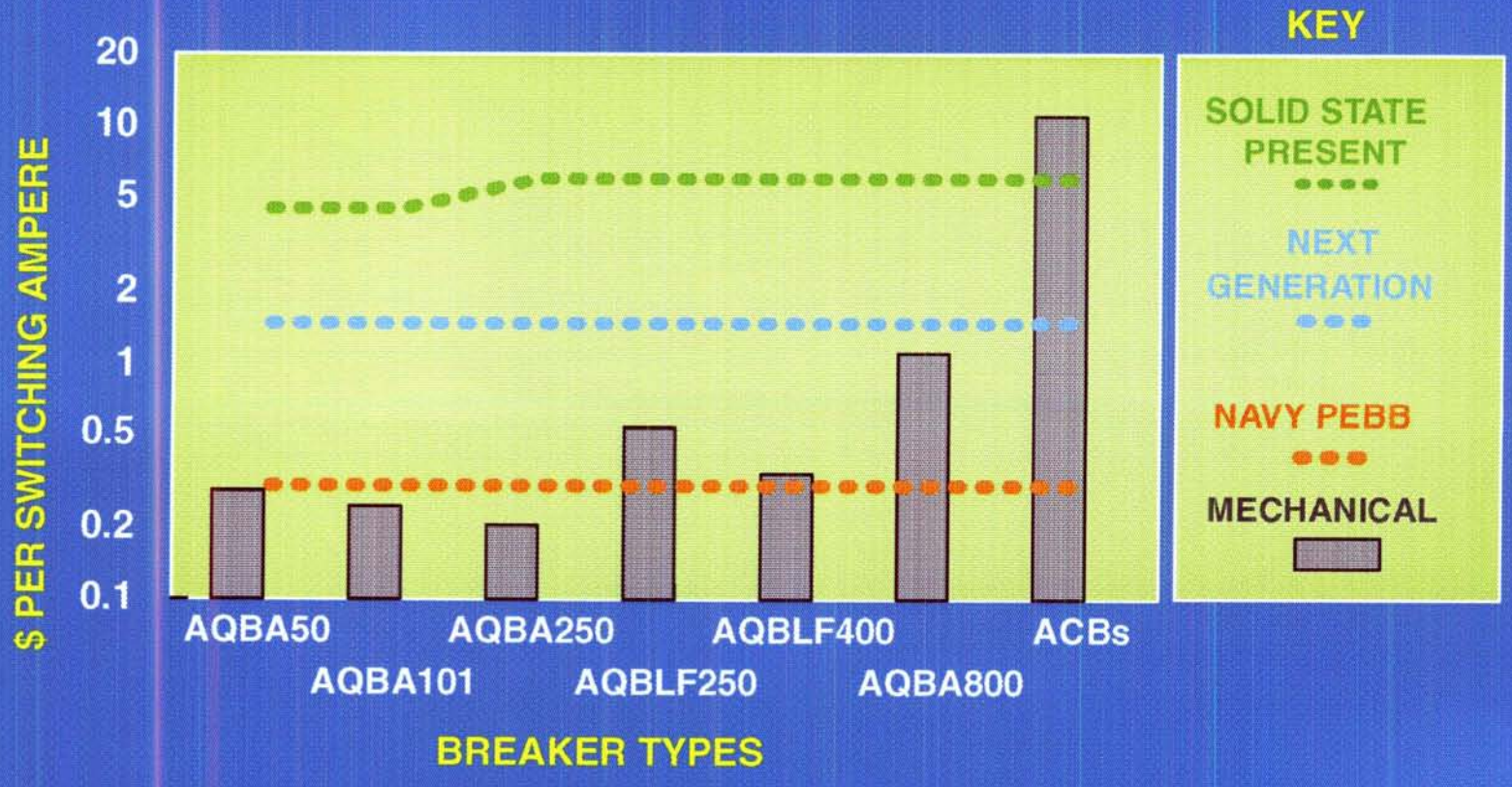


DISTRIBUTED ACTUATION:

- SAVE 70 TONS
- REDUCE HAZARD
- QUIET



PROTECTION DEVICES



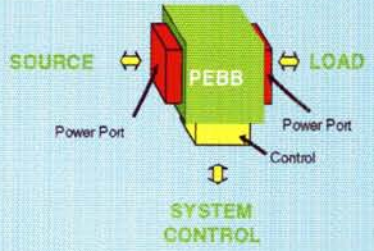
COMMONALITY MEANS REDUCED PIECE PARTS

"Second Electronic Revolution"

THE POWER ELECTRONIC BUILDING BLOCK (PEBB)

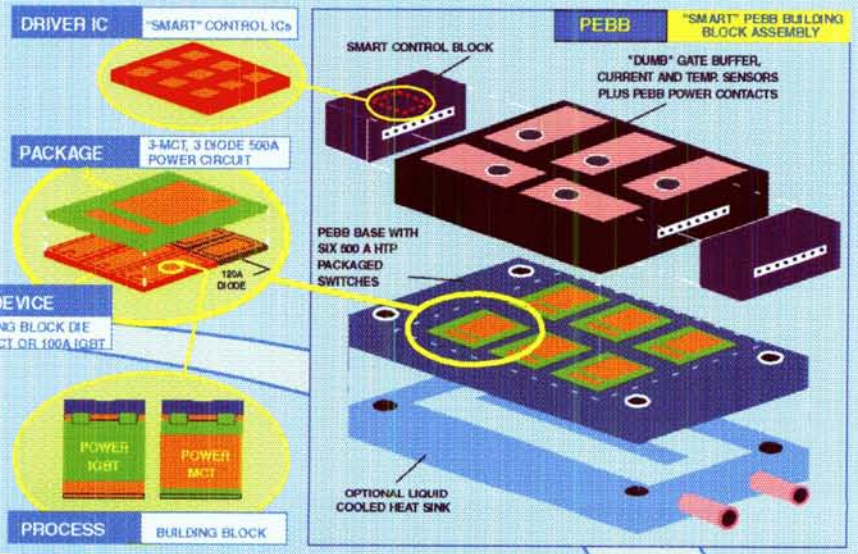
The "IC" of POWER CIRCUITS

- A single package multi-function controller that:
  - Replaces complex power electronic circuits with a single device
  - Reduces development and design costs for complex power circuits
  - Simplifies development and design of large electric power systems



SHIFT POWER ENGINEERING FROM CIRCUIT DESIGN TO SYSTEMS DESIGN

PEBB HARDWARE



- ***DIGITALLY CONTROLLED POWER***
- ***FLEXIBLE SYSTEM ARCHITECTURE***
- ***AUTOMATED MANUFACTURE***
- ***LOW COST***

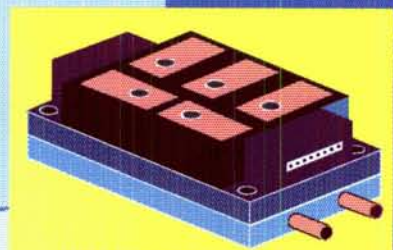
PEBB APPLICATIONS & DEVELOPMENT

SYSTEM CONTROL
Software Instruction
Feedback for Automation

PEBB Programmable for many APPLICATIONS

- BUS TRANSFER SWITCHES
- MOTOR CONTROLLERS
- CIRCUIT BREAKERS
- ACTUATORS
- ADJUSTABLE SPEED DRIVES
- POWER SUPPLIES
- INVERTERS - CONVERTERS

PEBB FUNCTIONS

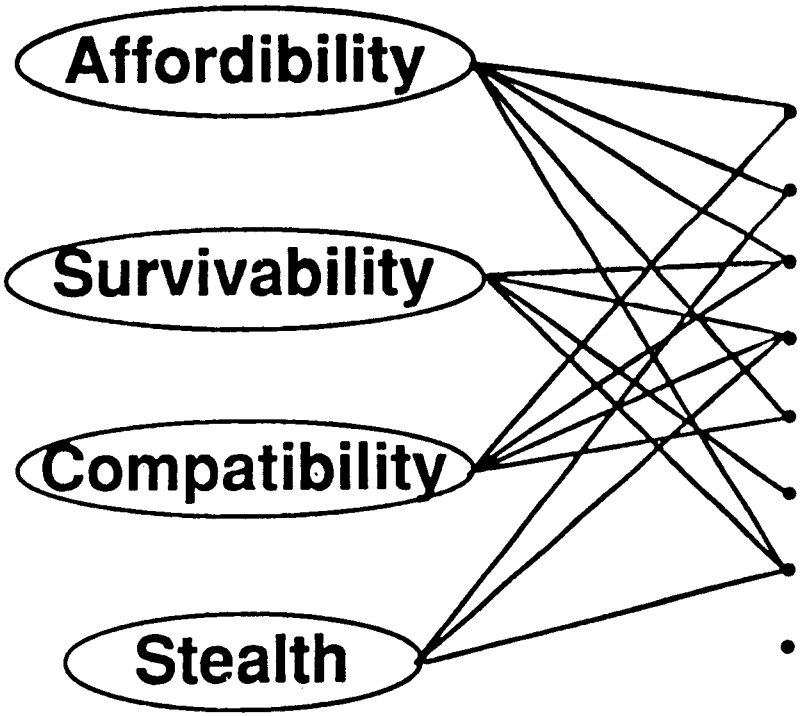


POWER ELECTRONIC BUILDING BLOCK

- GATE
- CURRENT SENSE
- DRIVE CHIP
- A/D
- MICRO-PROCESSOR
- CLOCK
- MEMORY
- Fo Tx
- Fo Rx
- Fo Tx
- Fo Rx
- FIBER OPTIC TRANSMIT & RECEIVE
- SERIAL I/O: DATA PROGRAMMING ADDRESSING

ELECTRIC POWER DISTRIBUTION R&D

THRUSTS



- Zonal Electrical Distribution Systems
- NAS Electric Plant
- AEGIS Electrical Distribution
- SEAWOLF Combat Power System
- NAVAIR Support Power Systems
- Electric Power Continuity
- Advanced Electric Power Distribution
- Special Projects

Networked Facilities "Behind the Scenes"

POWER ROOM (BLDG. 3)

- (2) 500 kW Motor-Generator Sets (DC/60 Hz)

MACHINERY SYSTEMS LABORATORY (BLDG. 100)

- 500 kW Turbine Emulator (DC/60 Hz)
- 100 kW Propulsion Derived Ship Service Generator (60 Hz)

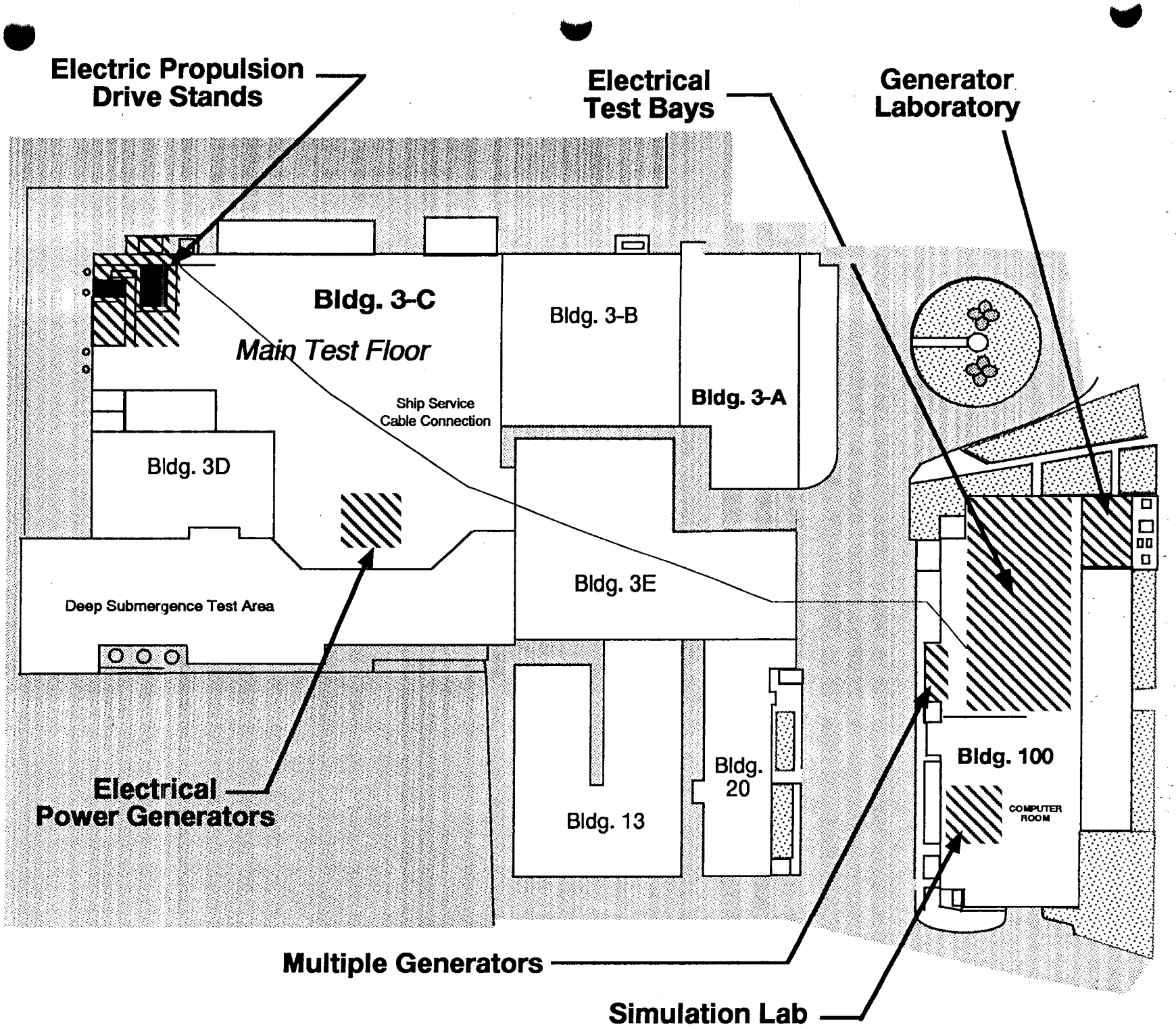
GENERATOR ROOM

- (2) 300 kW Matched Submarine Motor-Generators (DC/60 Hz)
- (3) Various kW Motor-Generator Sets (DC/400 Hz)

TEST FLOOR

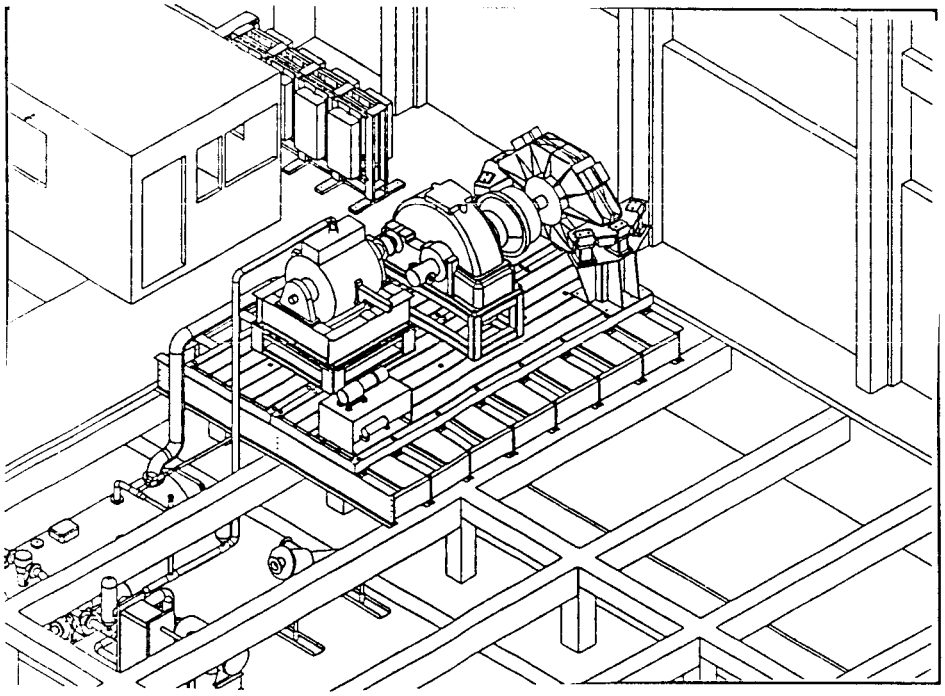
- (3) Solid-State Frequency Changers (60/400 Hz)
- 250 kW Battery Energy Storage System
- INTEGRATED Switchboard

ELECTRICAL SIMULATION LABORATORY

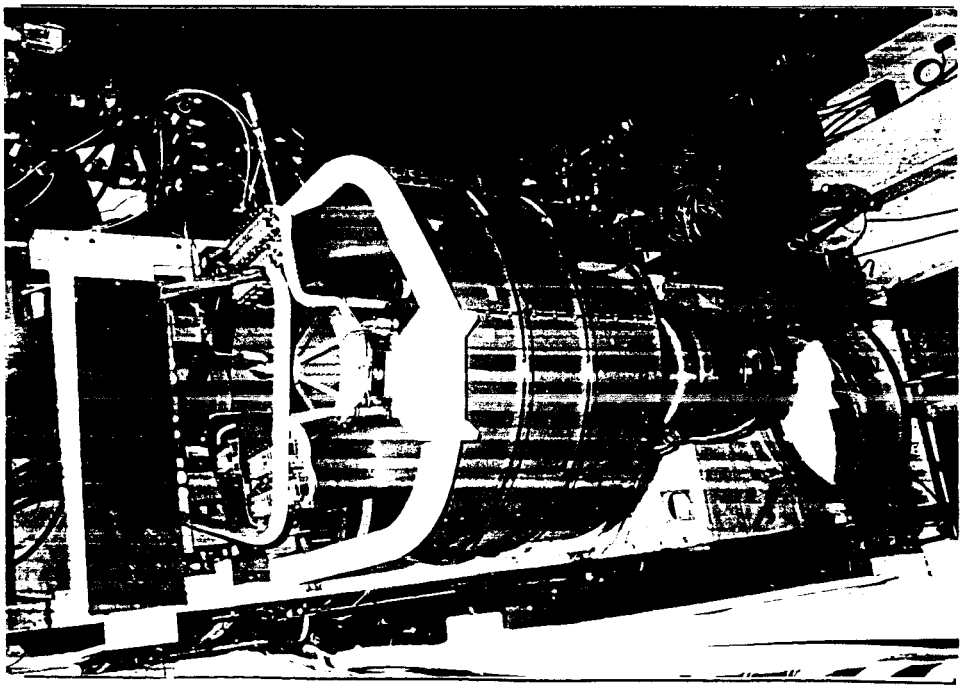

Electric Propulsion Drive Stands
Electrical Test Bays
Generator Laboratory
Bldg. 3-C
Main Test Floor
Bldg. 3-B
Bldg. 3-A
Ship Service Cable Connection
Bldg. 3D
Bldg. 3E
Deep Submergence Test Area
Electrical Power Generators
Bldg. 13
Bldg. 20
Bldg. 100
COMPUTER ROOM
Multiple Generators
Simulation Lab

3000 Hp Drive Test Rig

PM Electric Drive

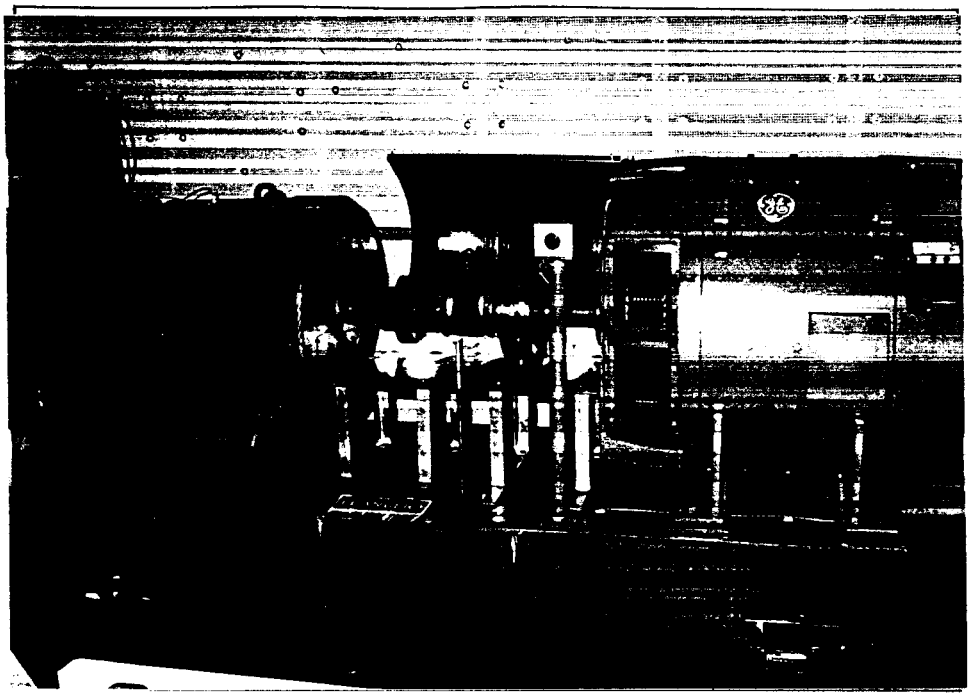


Turbine Drive & Water Brake

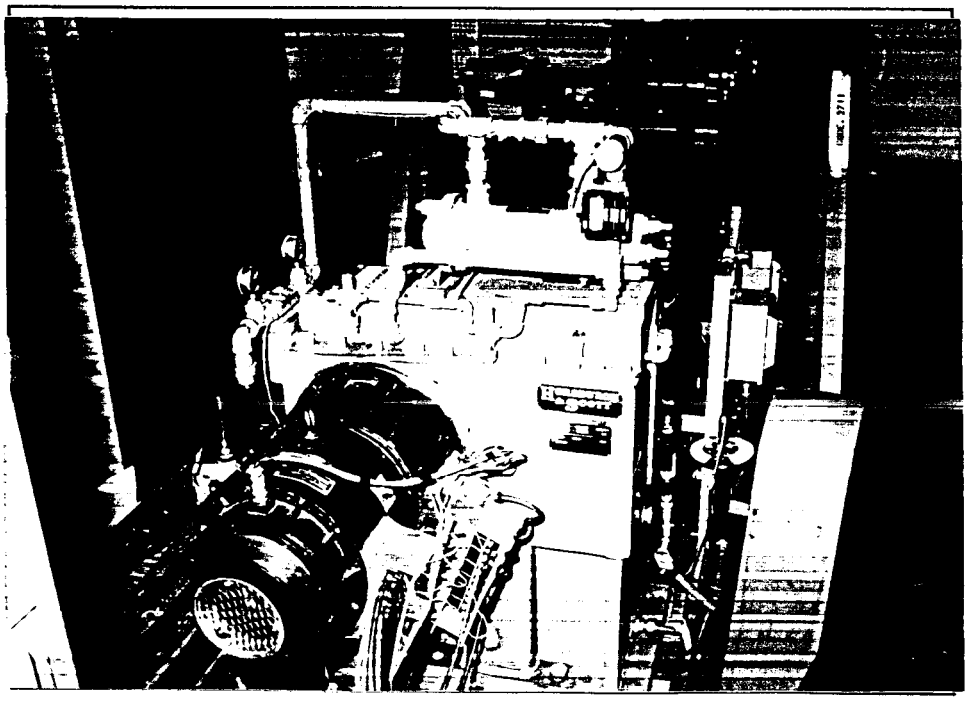


Machinery Systems Laboratory

500 kW Turbine Emulator

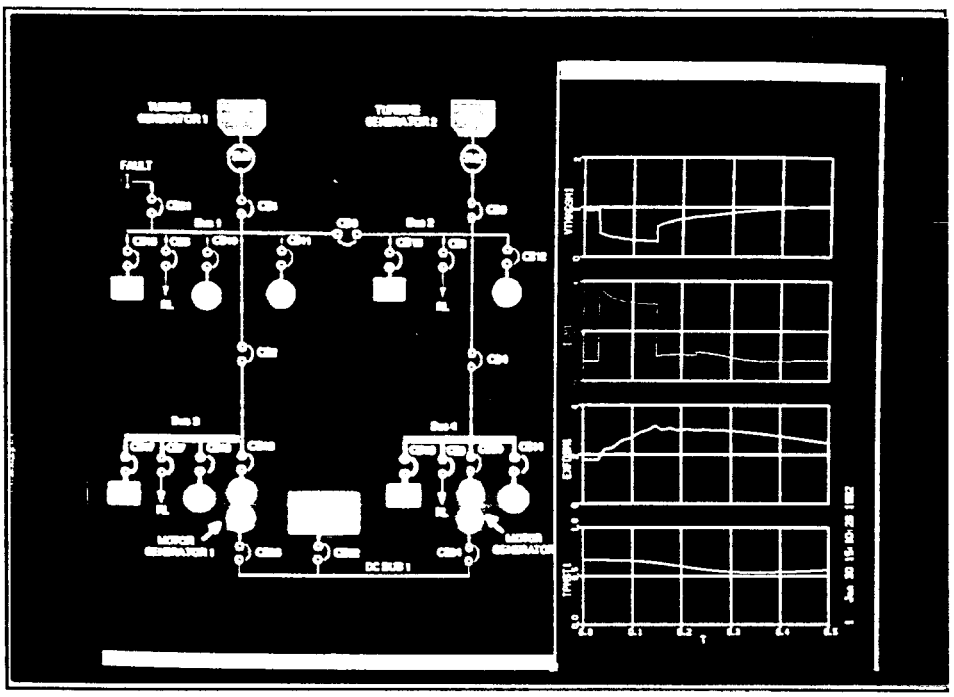


100kW Propulsion Derived Ship Service

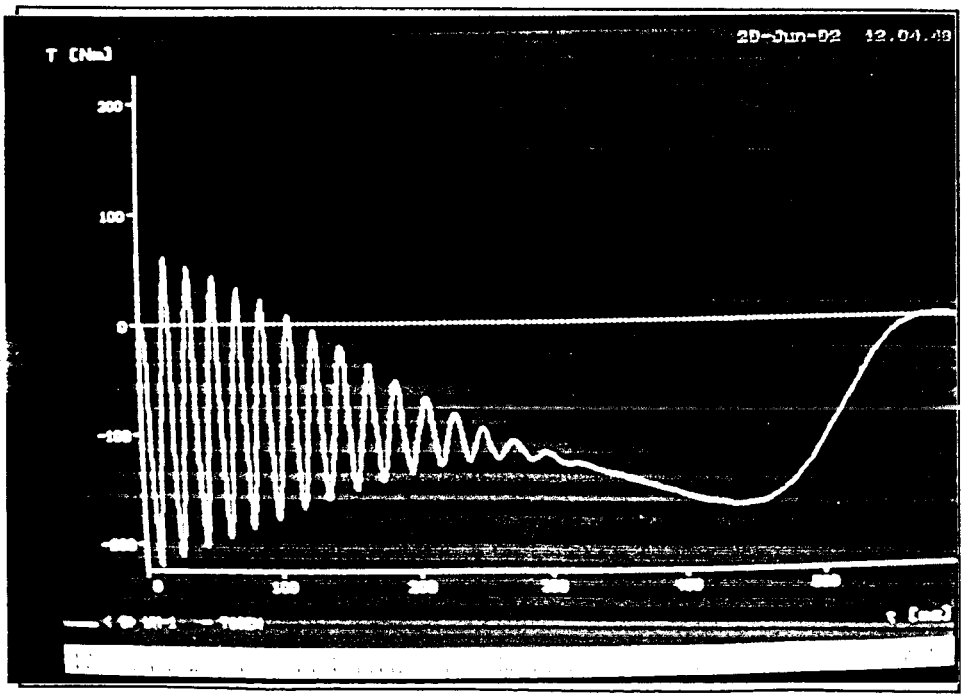


Simulation Laboratory

Electrical Systems & Equipments

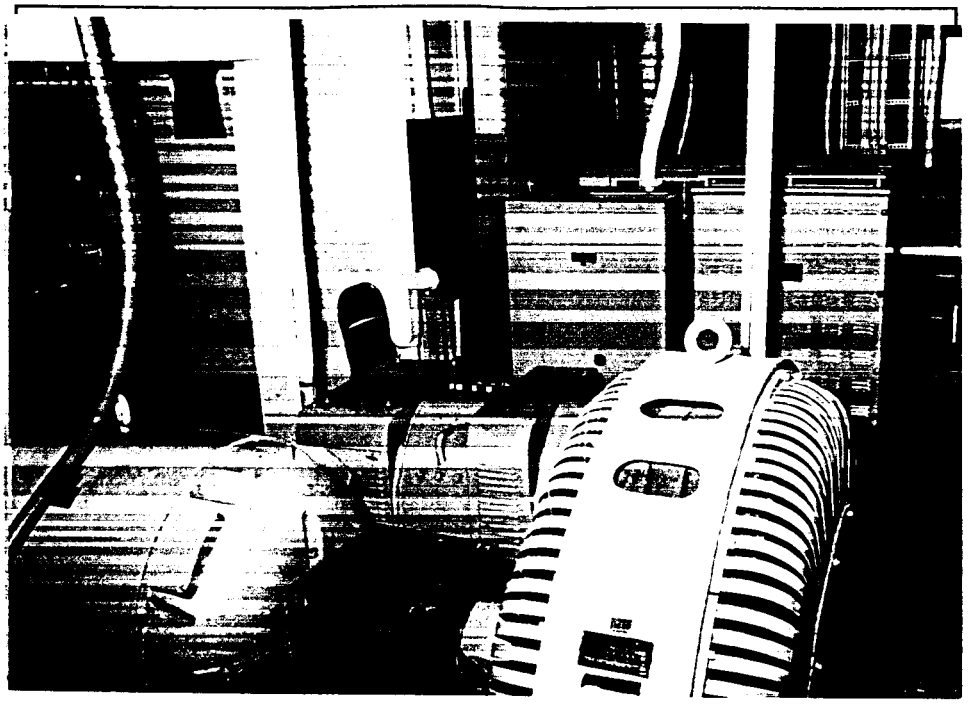


Equipment Components & Response

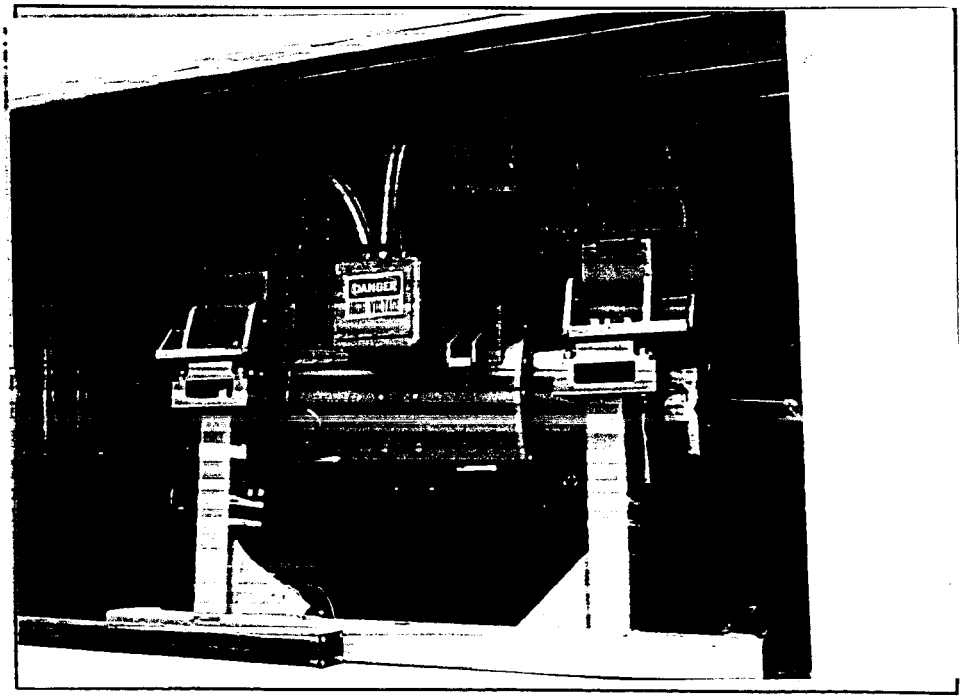


Generator Room

Multiple 60 Hz, 400 Hz and DC Generators

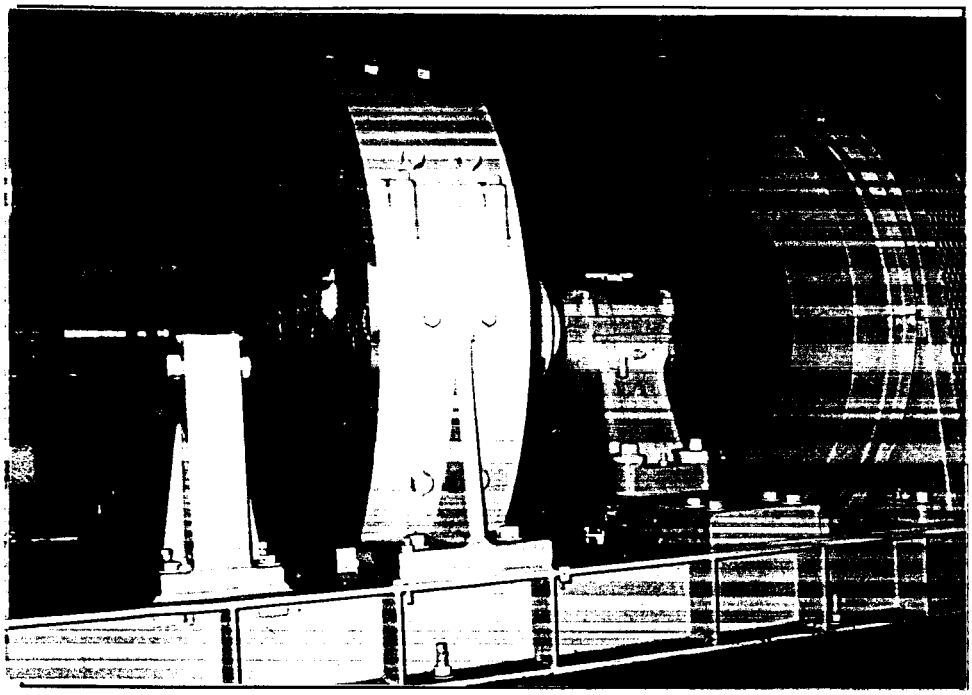


300 kW Motor-Generators (Matched Pair)

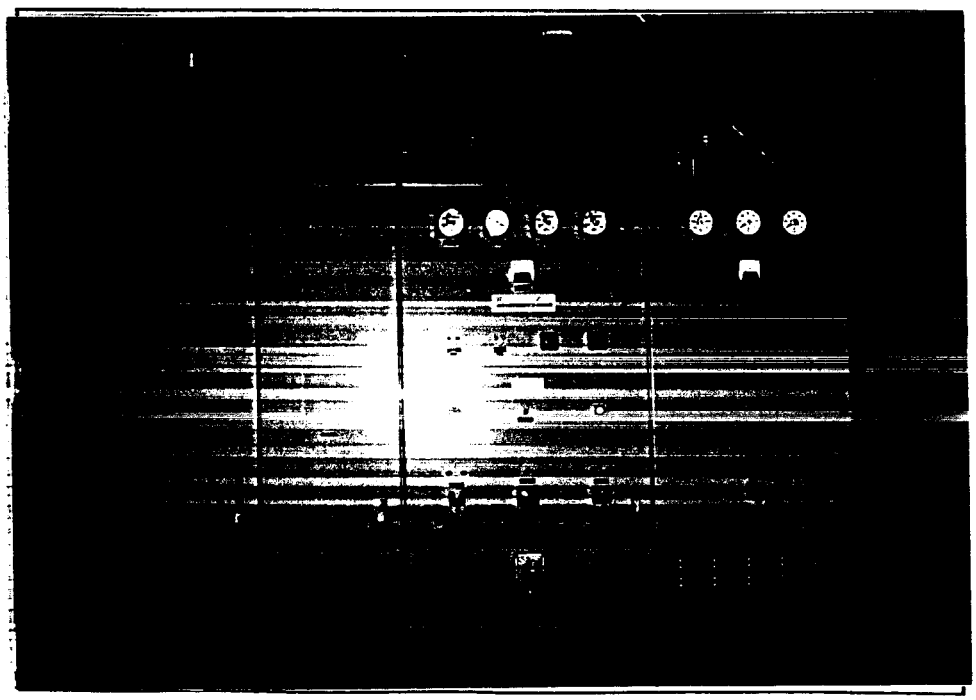


Electrical Power Supplies

500 kW Motor - Generator Sets

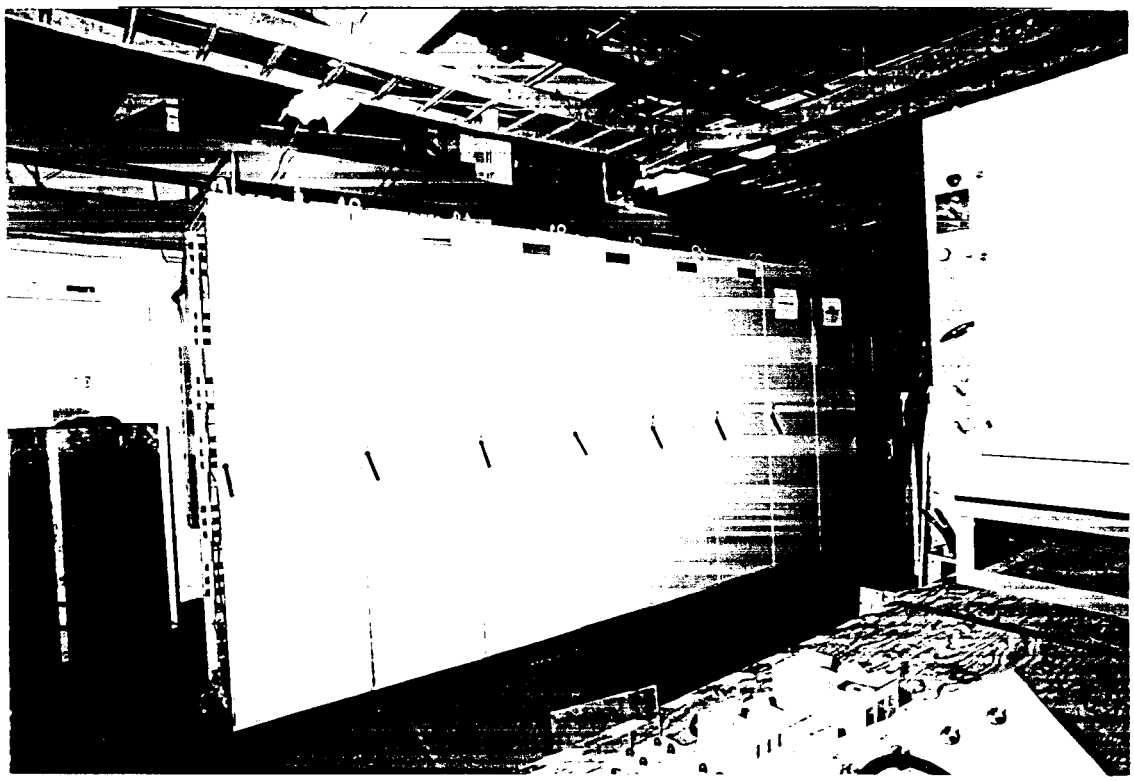


500 kW Switchboard

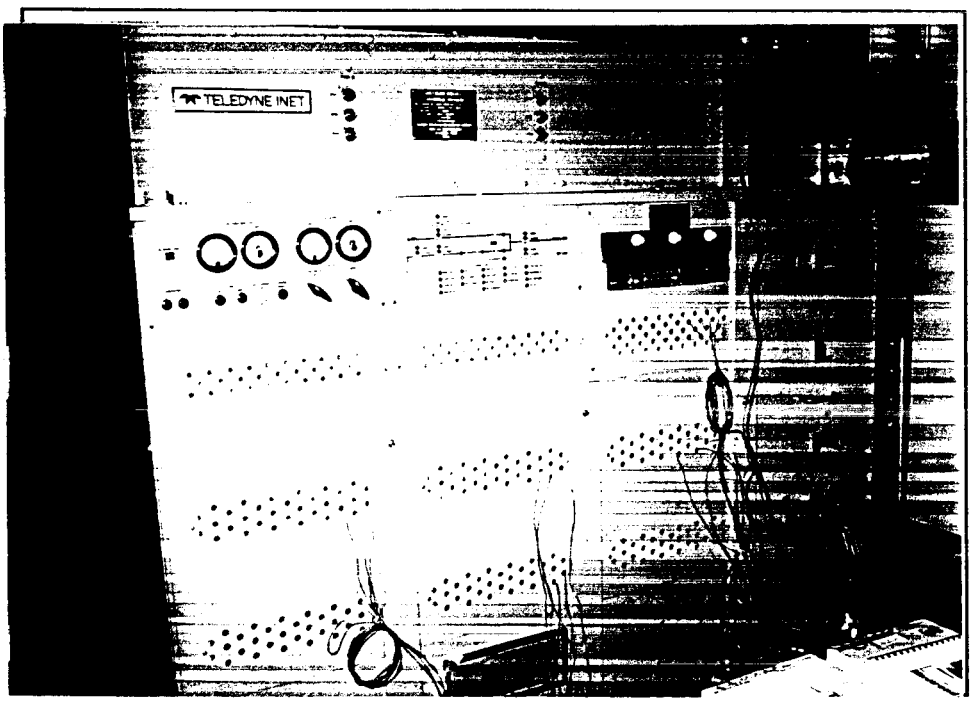


Laboratory & Test Bays

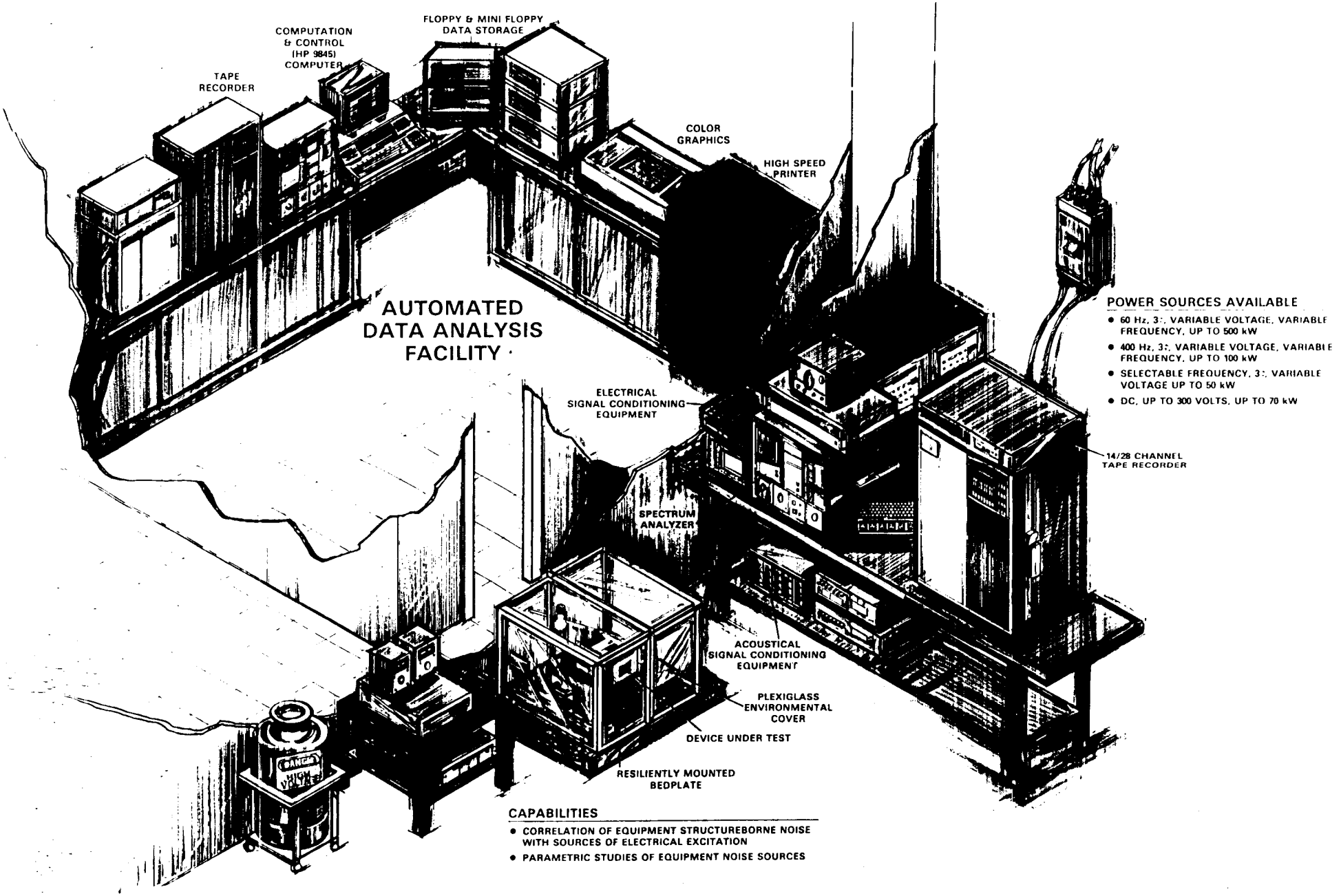
Integrated Switchboard



Battery Storage System



ELECTROACOUSTIC NOISE EVALUATION FACILITY



POWER SOURCES AVAILABLE

- 60 Hz, 3∅, VARIABLE VOLTAGE, VARIABLE FREQUENCY, UP TO 500 kW
- 400 Hz, 3∅, VARIABLE VOLTAGE, VARIABLE FREQUENCY, UP TO 100 kW
- SELECTABLE FREQUENCY, 3∅, VARIABLE VOLTAGE UP TO 50 kW
- DC, UP TO 300 VOLTS, UP TO 70 kW

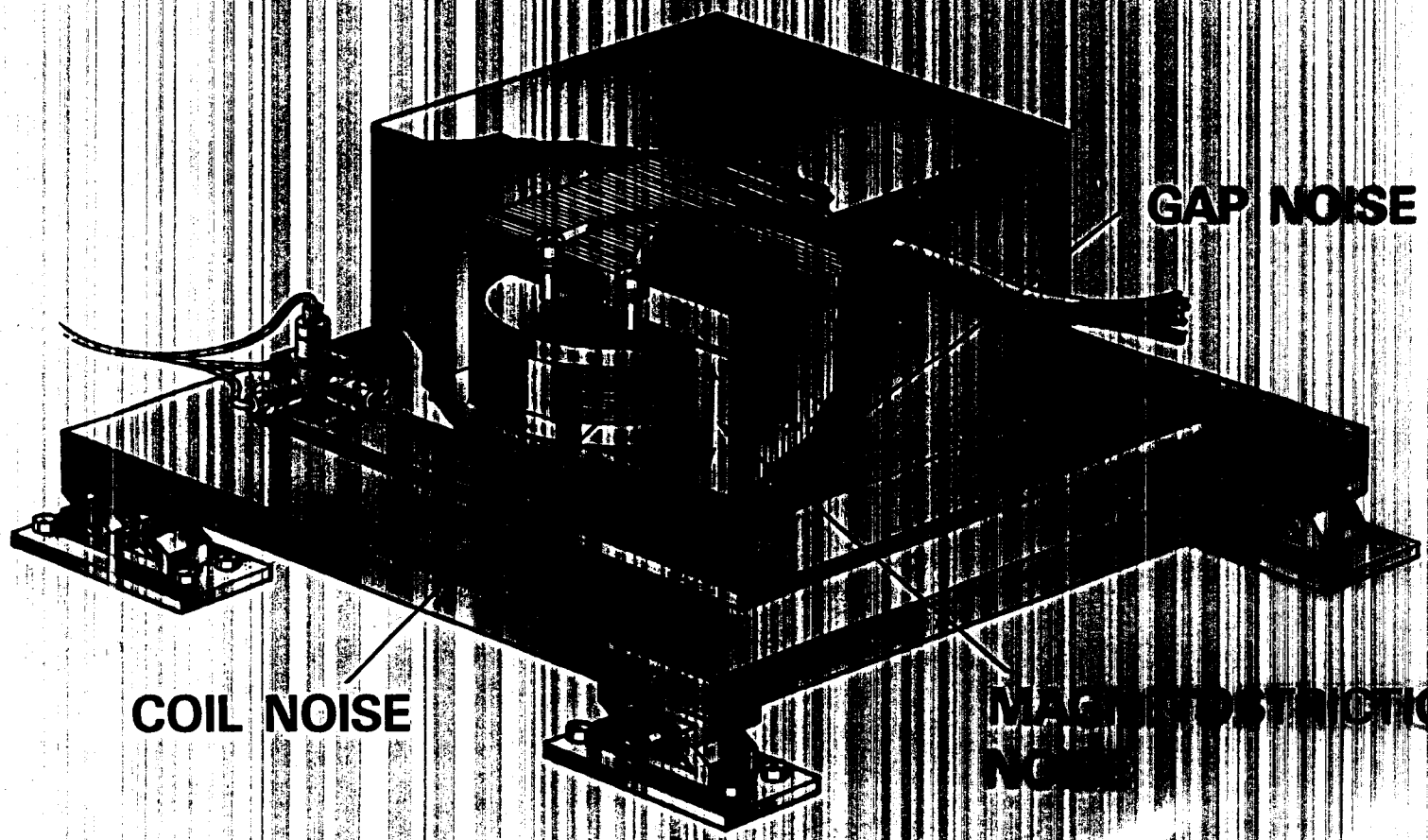
CAPABILITIES

- CORRELATION OF EQUIPMENT STRUCTUREBORNE NOISE WITH SOURCES OF ELECTRICAL EXCITATION
- PARAMETRIC STUDIES OF EQUIPMENT NOISE SOURCES

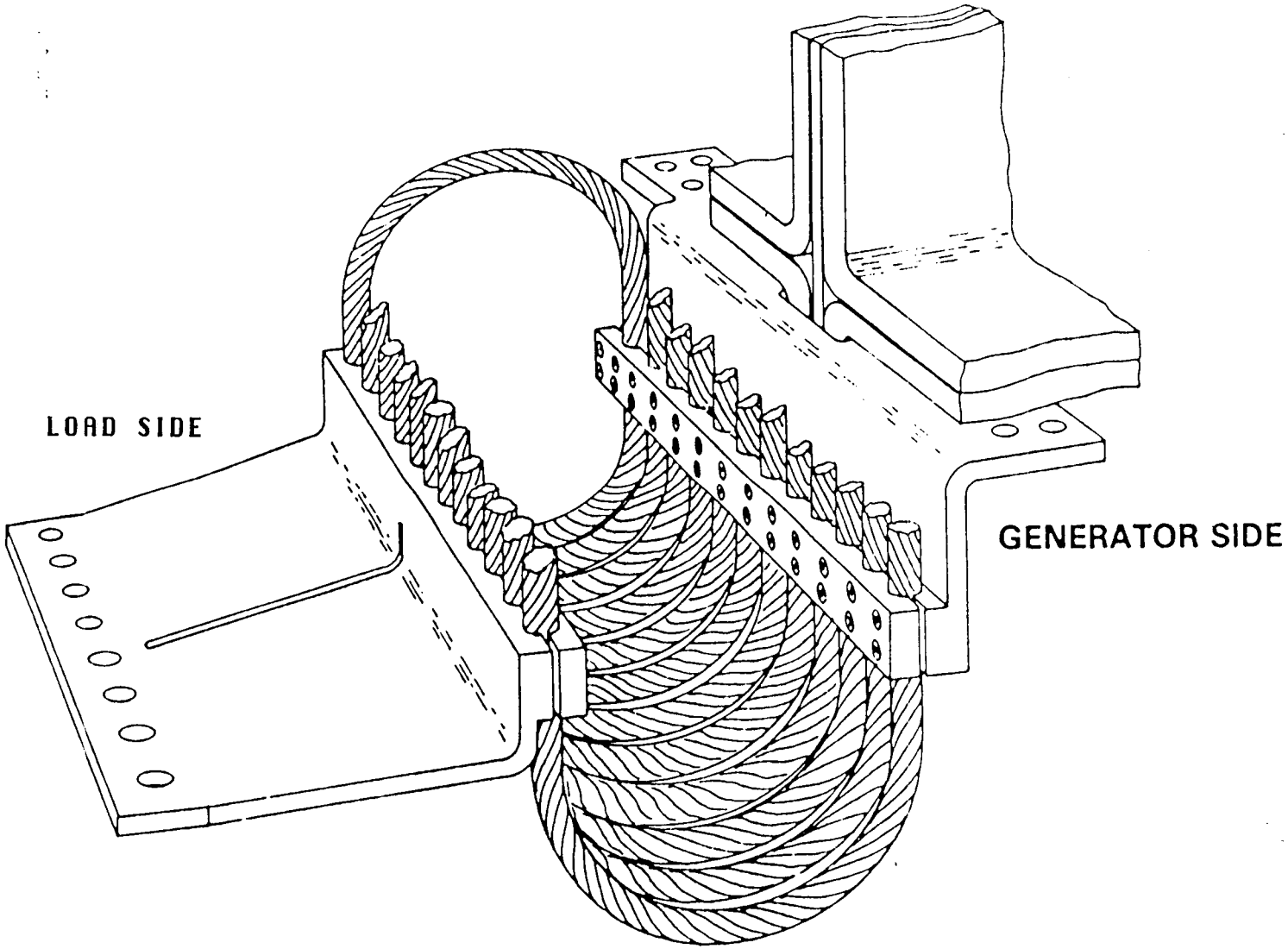
ELECTROACOUSTIC PROGRAM

OBJECTIVE: CONDUCT R&D, DEVELOP, INSTALL, AND EVALUATE EQUIPMENT TO REDUCE DISCRETE RADIATED NOISE GENERATED BY SHIPBOARD ELECTRICAL SYSTEMS

SSN 21 QUIET COMPONENT STUDY
TRANSFORMER NOISE SOURCE

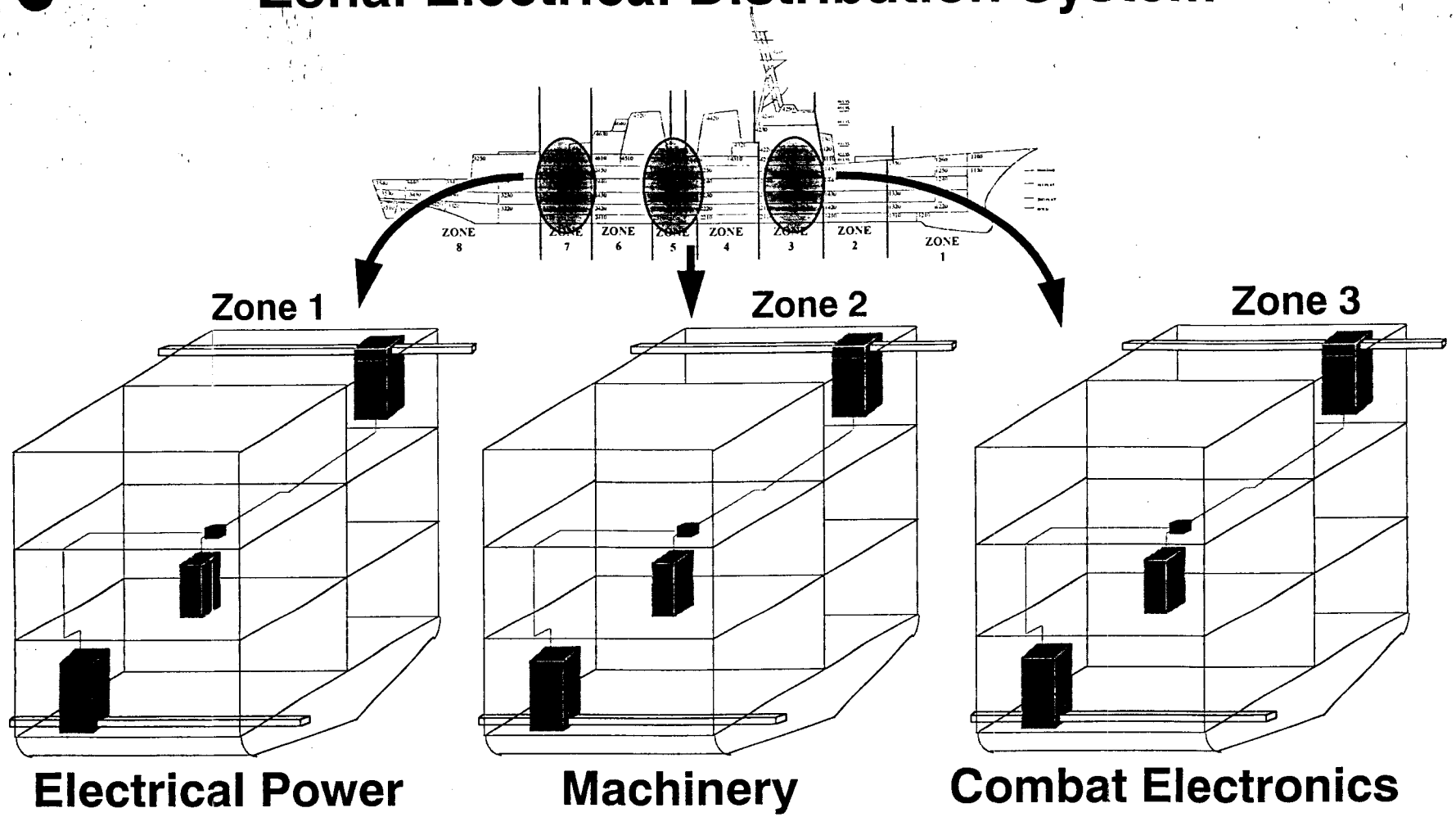


PROTOTYPE ISOLATOR/CONNECTOR FOR SSTG APPLICATION



Electrical connector provides good electrical conductivity as well as acoustical isolation

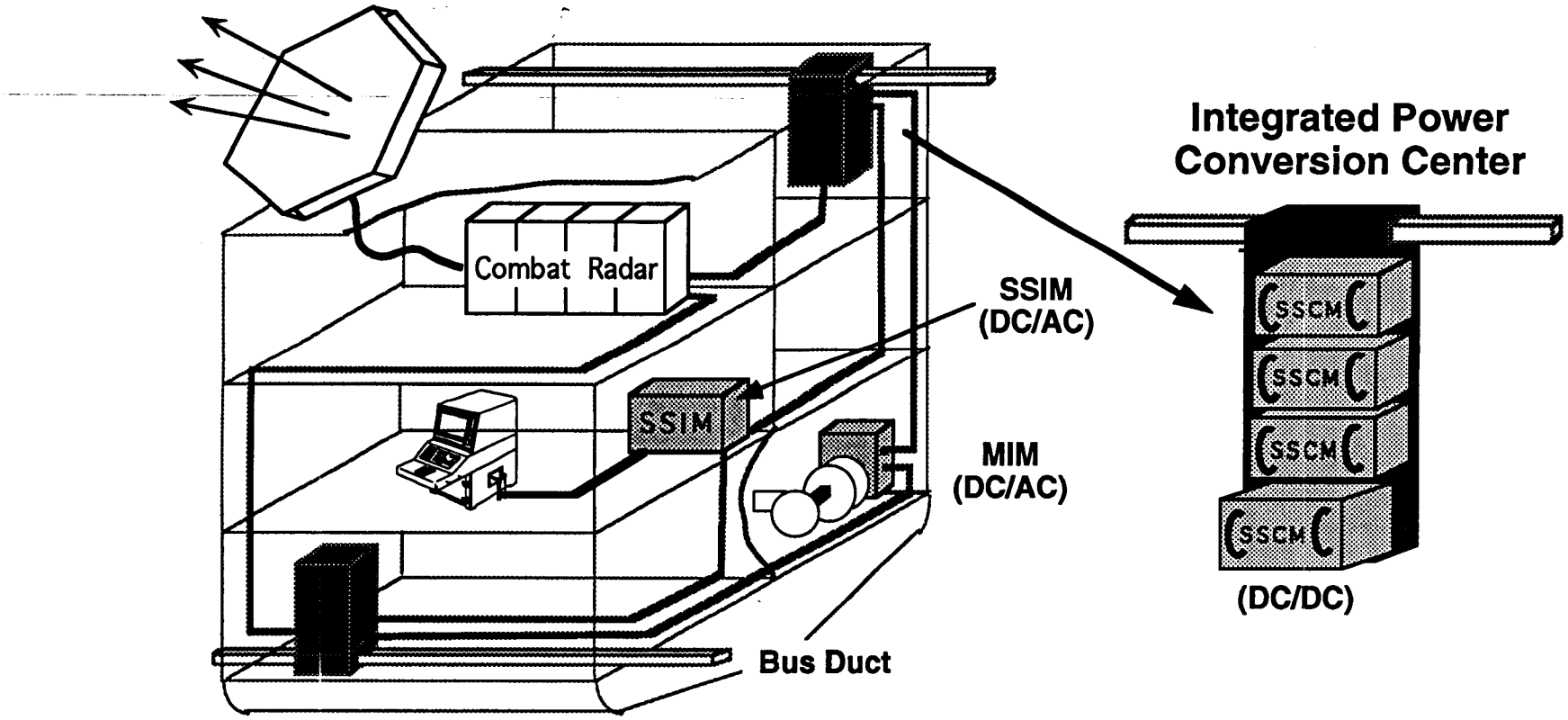
Zonal Electrical Distribution System



Reduced Scale Shipboard System

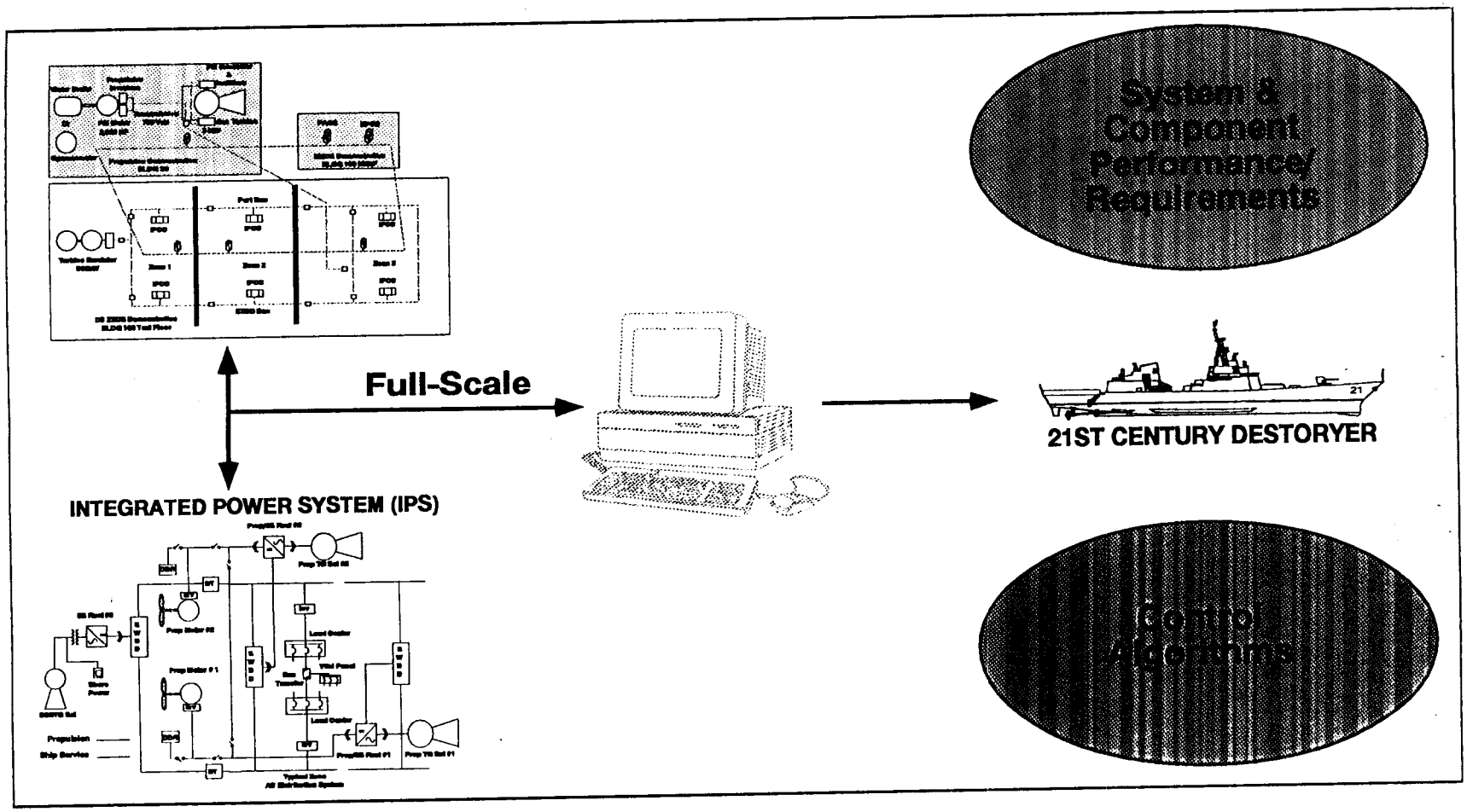
ZONAL Electrical Distribution Systems

Integration with Combat & Auxiliaries



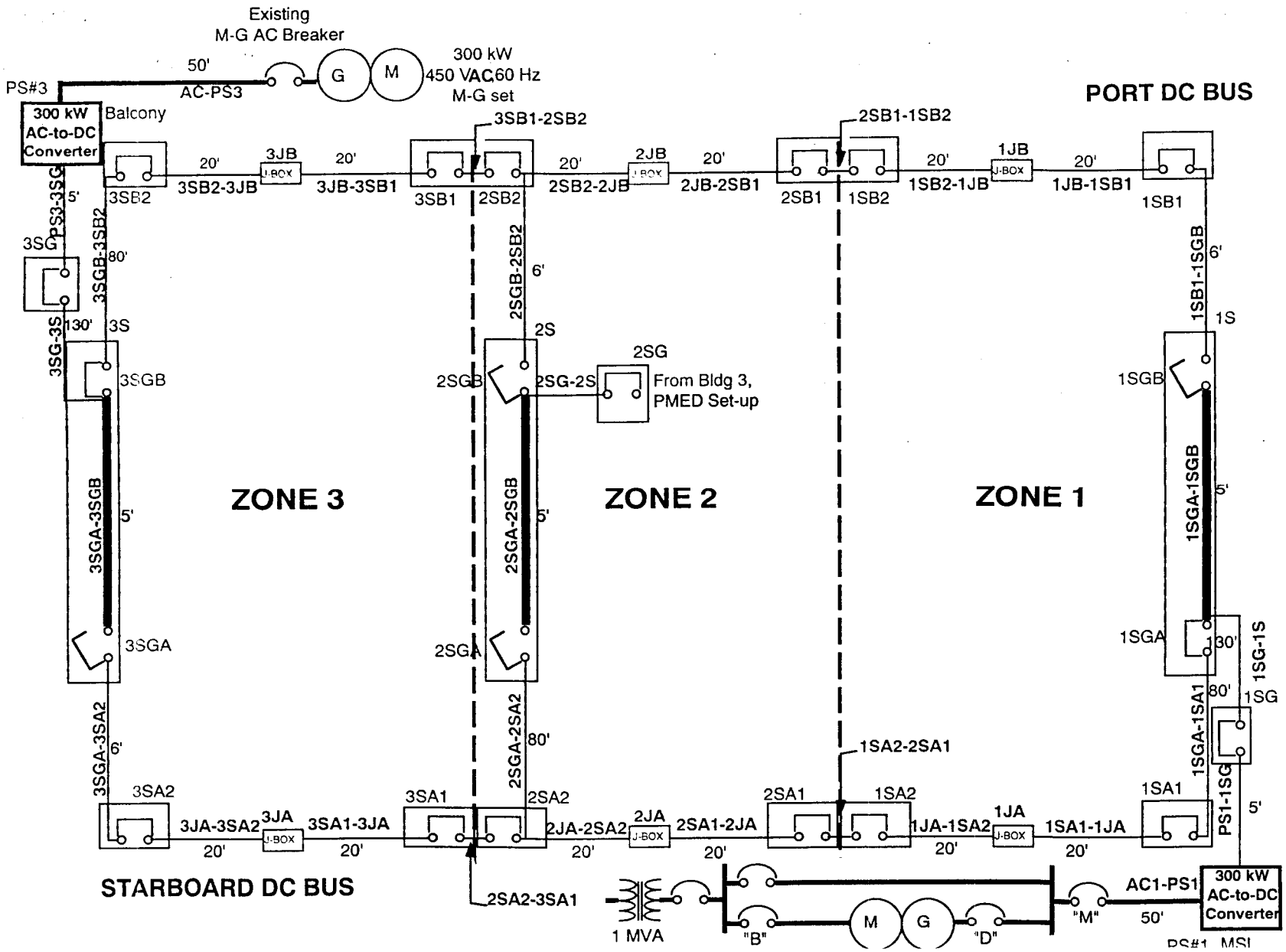
Integrated Protection, Regulation & Management = FEWER PARTS

IPS SYSTEM INTEGRATION



ZEDS TEAM
HJH:NAVSEA 05Z
2/11/93

DC ZEDS 3-Zone Test Facility



Propulsion Derived Ship Service (PDSS)

- Ship service power derived from the propulsion drive train rather than a stand alone generator set.

- PDSS BENEFITS

  - FUEL SAVINGS - 10% TO 15% IMPROVEMENT

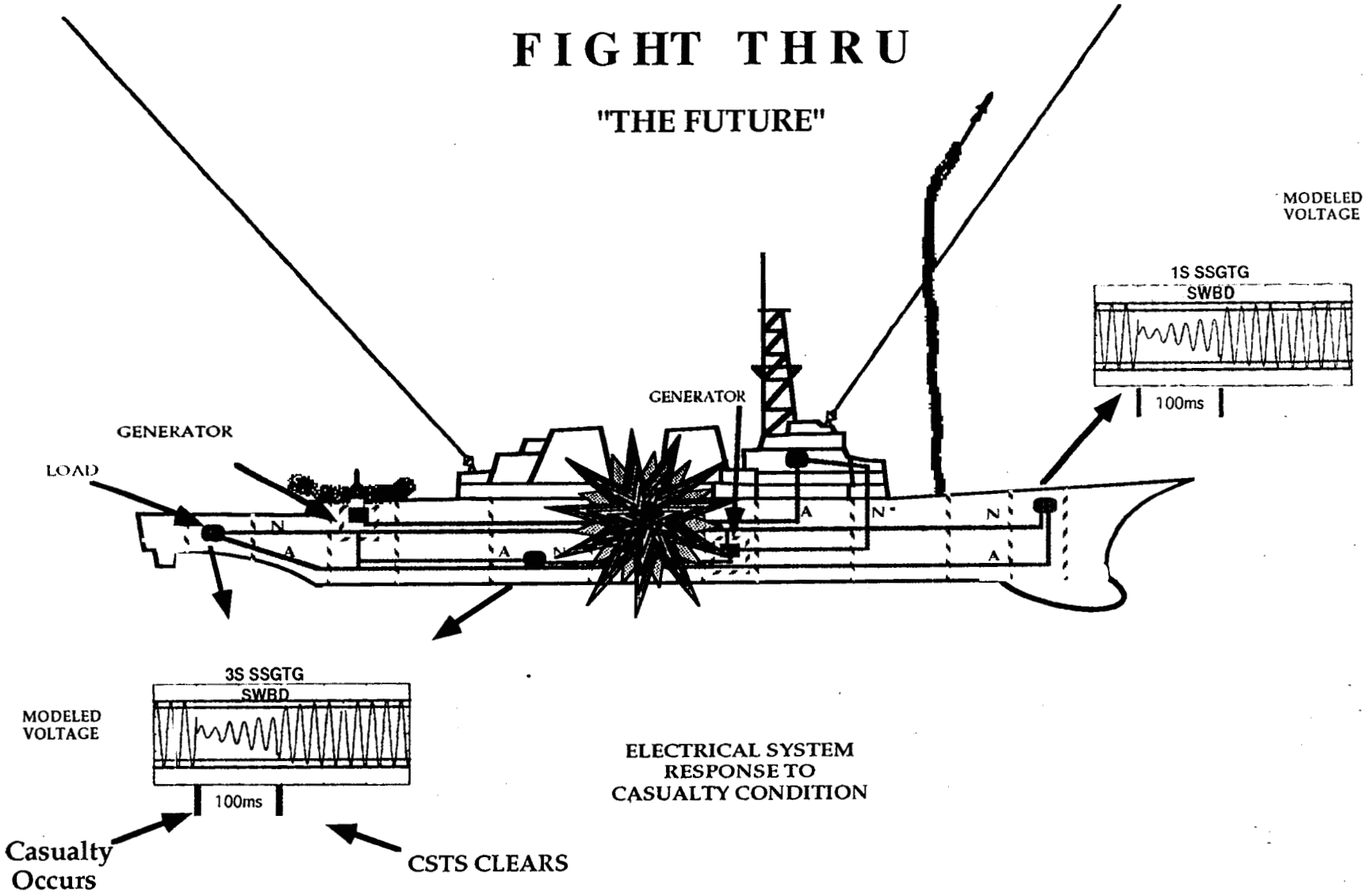
  - LONGER RANGE OR INCREASED TANKAGE

  - ARRANGEMENT FLEXIBILITY
    - LESS SPACE AND WEIGHT

  - ELIMINATES GAS TURBINE OR DIESEL ENGINES

FIGHT THRU

"THE FUTURE"



ELECTRICAL SYSTEM RESPONSE TO CASUALTY CONDITION

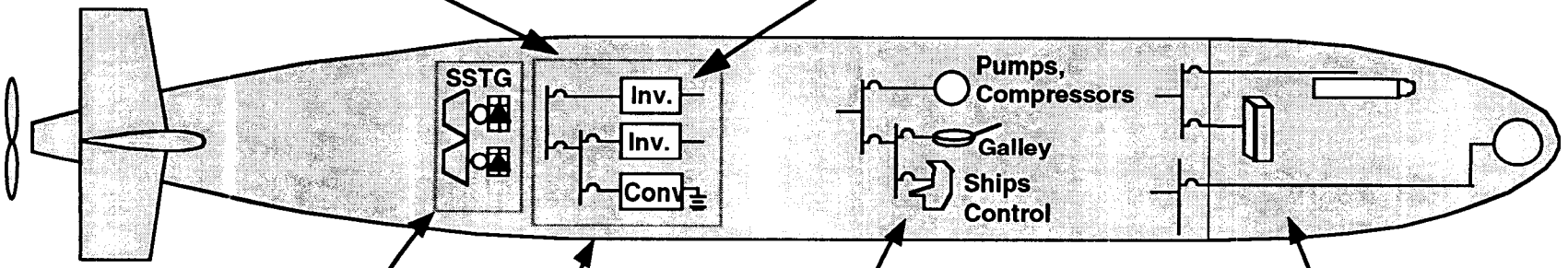
ELECTRICAL SYSTEM RESPONCE TO CASUALTY WITHIN 100ms TO KEEP UNDAMAGED COMBAT EQUIPMENT FIGHTING THRU

NSWC
Naval Surface Warfare Center
CARDEROCK DIVISION

NSSN
AREAS OF SUPPORT

DC Electric Plant System Design
- Design Review
- Specification Review
- Computer Simulation.

700VdcCircuit Breakers
- Design Review
- Computer Simulation



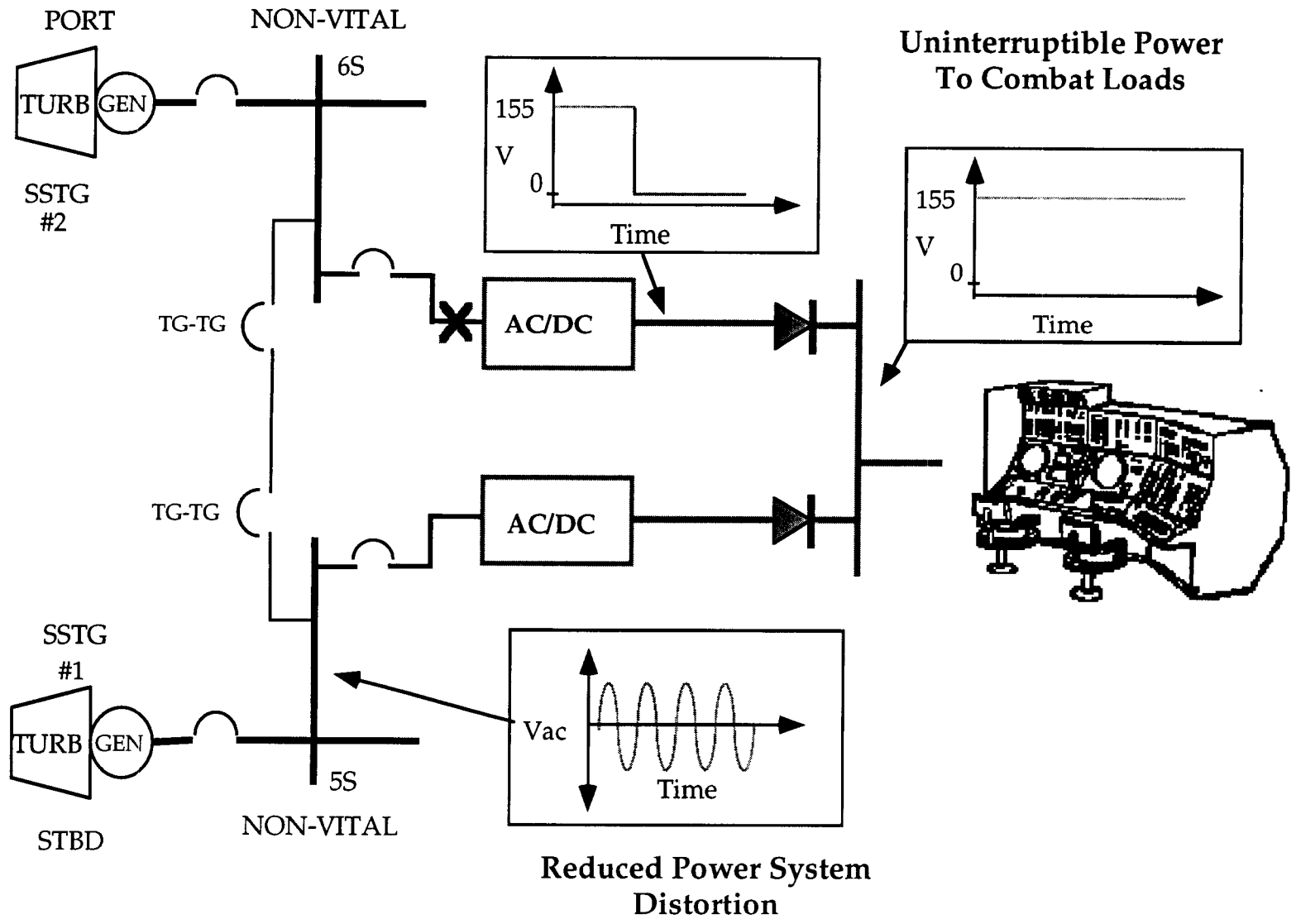
SSTG
- Design Review
- Computer simulation

AQB Circuit Breakers
- Improving Breaker Trip Characteristics

700VdcCircuit Breakers
- Modification of Navy ACB-4000 Breaker.

Combat System Electrical Power
- Compatibility with AMP Modules

PRIMARY PERFORMANCE REQUIREMENTS

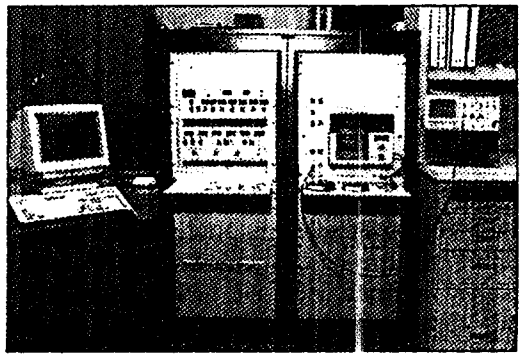


especially in shallow water, which will allow effective and safe landing operations. Superconductive machinery, because of its small size and high performance, will increase capability and has the potential for significant cost savings. There is a close working relationship with industry and universities which makes possible accelerated developments, quick commercialization and an improved American competitiveness in this technology area.

ELECTRICAL EQUIPMENT AND CABLE TECHNOLOGY BRANCH

Mr. Gene Dadin
(410) 267-2260

The Electrical Equipment and Cable Technology Branch (Code 813) executes research and development programs for electrical system components. The goal is to obtain performance that is affordable to the Navy. Emphasis is on power electronics including application guidance on power semiconductors and high frequency synthesis power conditioners controlled by microprocessors. The branch also conducts research on system protection components such as solid-state circuit breakers and ramp motor starters.

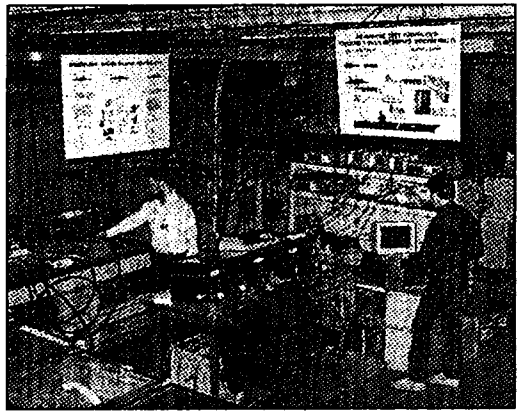


In-house capabilities include: industry-standard equipment for characterizing power semiconductors, electrical hardware simula- [illegible] the design and fabrication of solid-state power conditioning/conversion equipment, and [illegible] control of power equipment.

POWER DISTRIBUTION SYSTEMS BRANCH

Mr. David Clayton
(410) 267-2467

The Power Distribution Systems Branch (Code 814) provides design and analysis of shipboard electrical power systems to improve the system affordability while equaling or improving performance. Branch expertise includes power continuity, power quality, system control, and stability.



The branch supports the integration of high-efficiency power-dense electric sources, converter-fed distribution systems, and sensitive load equipment. Component and systems testing up to approximately 2 megawatts is accomplished in the Power Distribution Laboratory. Laboratory and shipboard testing is augmented by an extensive and flexible computer simulation environment to predict performance and develop requirements for conceptual systems and components.

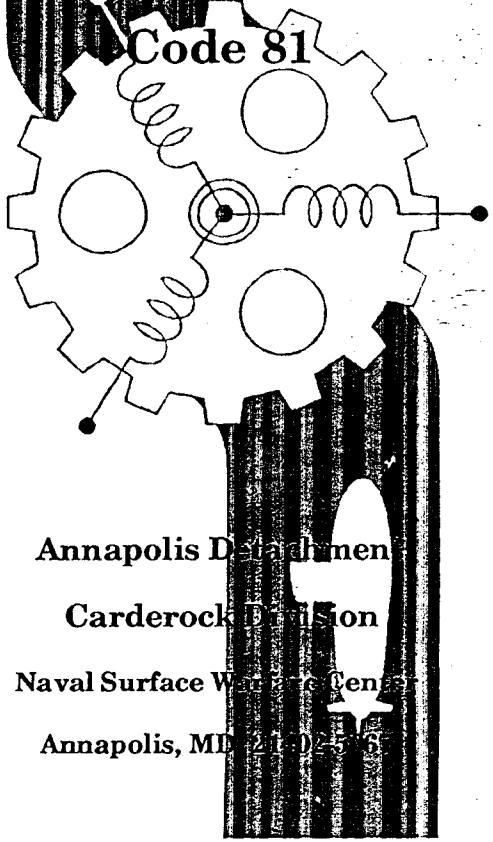
Approved for public release
July 1993
Distribution unlimited

L R Walker

Commander L.H. Walker
Officer in Charge
Carderock Division, NSWC

Electrical Systems Department

Code 81



Annapolis Detachment
Carderock Division
Naval Surface Warfare Center
Annapolis, MD [illegible]

ELECTRICAL SYSTEMS DEPARTMENT

Mr. Howard O. Stevens, Jr.
(410) 267-2857
FAX (410) 267-2571

The Electrical Systems Department (Code 81) is the Navy's primary internal resource for the conduct of research and development in electrical power systems for surface ships and submarines. Efforts ongoing include development of electrical propulsion systems, electrical power generation and distribution systems, and the individual machines, control components, and supporting equipment for such systems. The focus of our work is to introduce new technology and design approaches which improve the affordability of Navy ships while maintaining or enhancing performance. The Department's primary customers include the Naval Sea Systems Command for new system/ship design support and some fleet problem solving, the Office of Naval Research for research and exploratory development, and the Advanced Research Projects Agency. A small but increasing percentage of our work is conducted for private industry.

The Department employs approximately 100 electrical and mechanical engineers, physicists, technicians, and support personnel, over 20% of whom have advanced degrees. These personnel have an average of over 15 years of experience in electrical power technology. Over 30,000 square feet of fully equipped laboratory and test facilities are available for the research, development, and testing of electrical power equipment and systems. Extensive capability also exists for computer modeling and simulation of electrical systems and components. This capability can be augmented through contracts to accomplish tasks requiring resources beyond those available in-house.

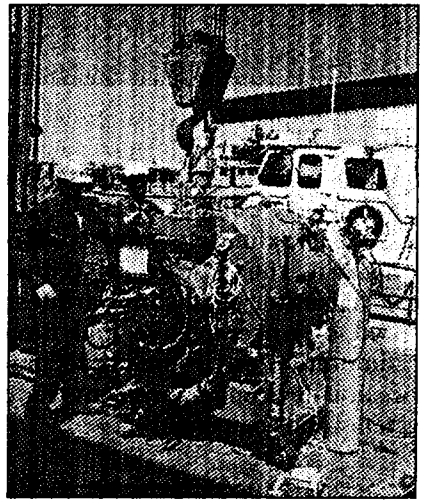
Technologies under investigation include new solid state power devices, applications of superconductivity to electrical machines and minesweeping, solid state power converters, new electrical system architectures, permanent magnet machinery, cryogenic refrigeration systems, new designs for circuit breakers, and electrical system coordination.

Following are summaries of the capabilities of the Department's four branches, which are available to help solve your problems.

ELECTRICAL PROPULSION AND MACHINERY SYSTEMS BRANCH

Mr. Robert C. Smith
(410) 267-2868

The Electrical Propulsion and Machinery Systems Branch (Code 811) designs, analyzes, and evaluates new concepts in electrical propulsion systems and electrical machinery. Optimum machine and system designs are established through parametric analyses, experimental machine development, and hardware testing.



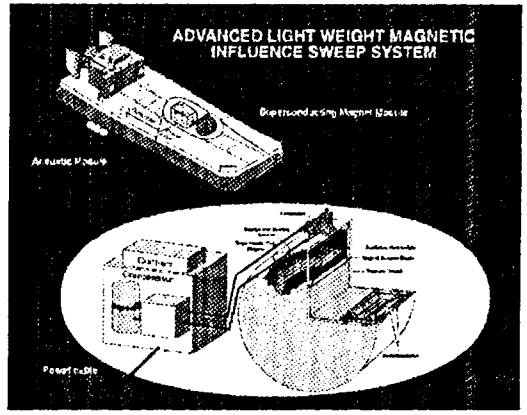
The branch can also provide thermal, magnetic and electro-mechanical modeling of conventional AC motors and generators as well as homopolar, permanent magnet, and superconducting machines. The branch has designed, built, and tested machinery up to 3000 hp capacity in-house and has access to this capability at virtually any power level.

Specific capability is available to do integrated system design and provide assessments of affordability and technical risk. The branch also has over 20 years of experience in analyzing and correcting causes of electrically generated acoustic noise in electrical equipment and has developed low noise equipment for shipboard use.

ELECTRICAL MACHINERY TECHNOLOGY BRANCH

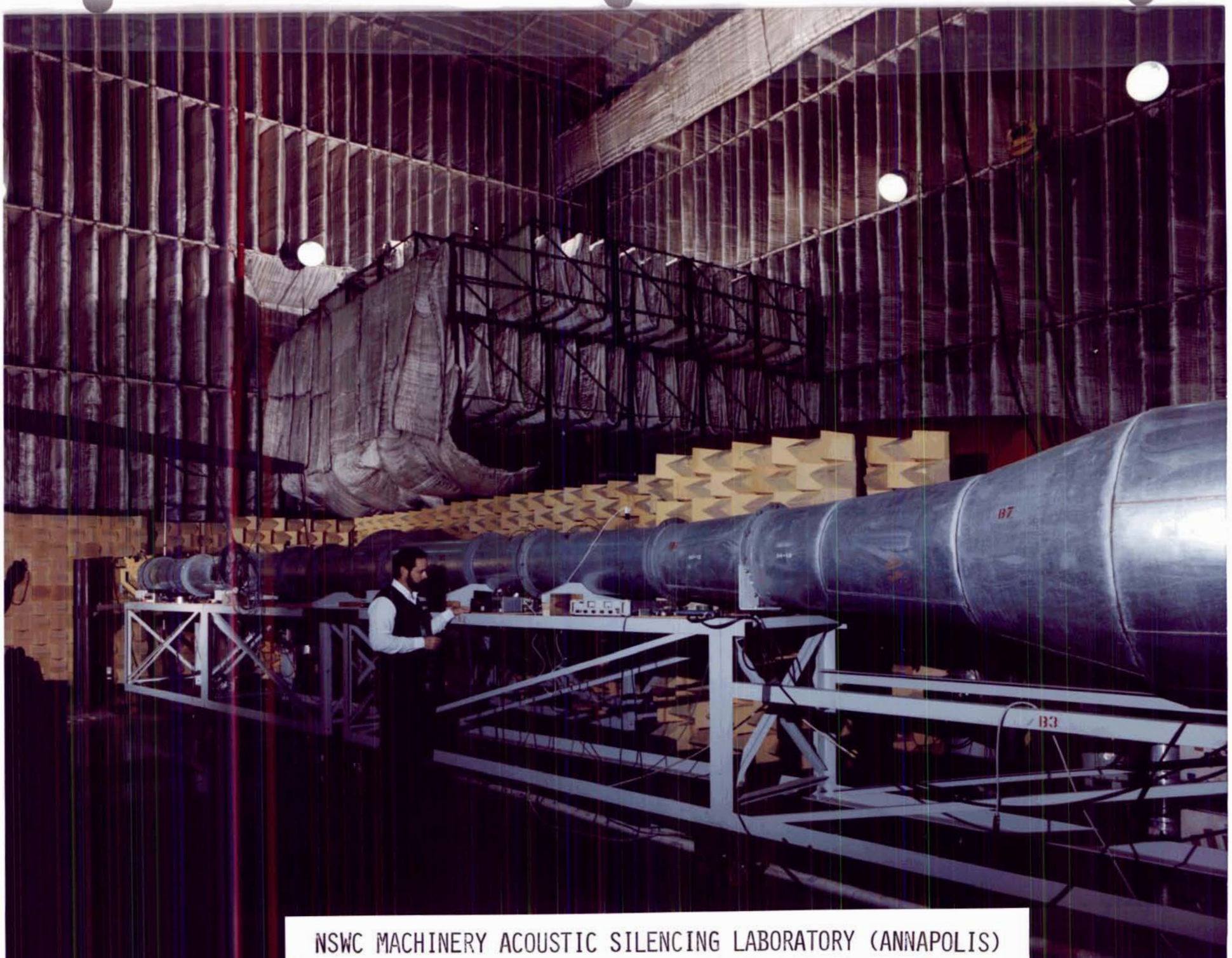
Mr. Michael Superczynski
(410) 267-2149

The Electrical Machinery Technology Branch (Code 812) provides research and development for systems and components that use superconductive technology. These include electric motors and generators, energy storage, and magnetic minesweeping systems.

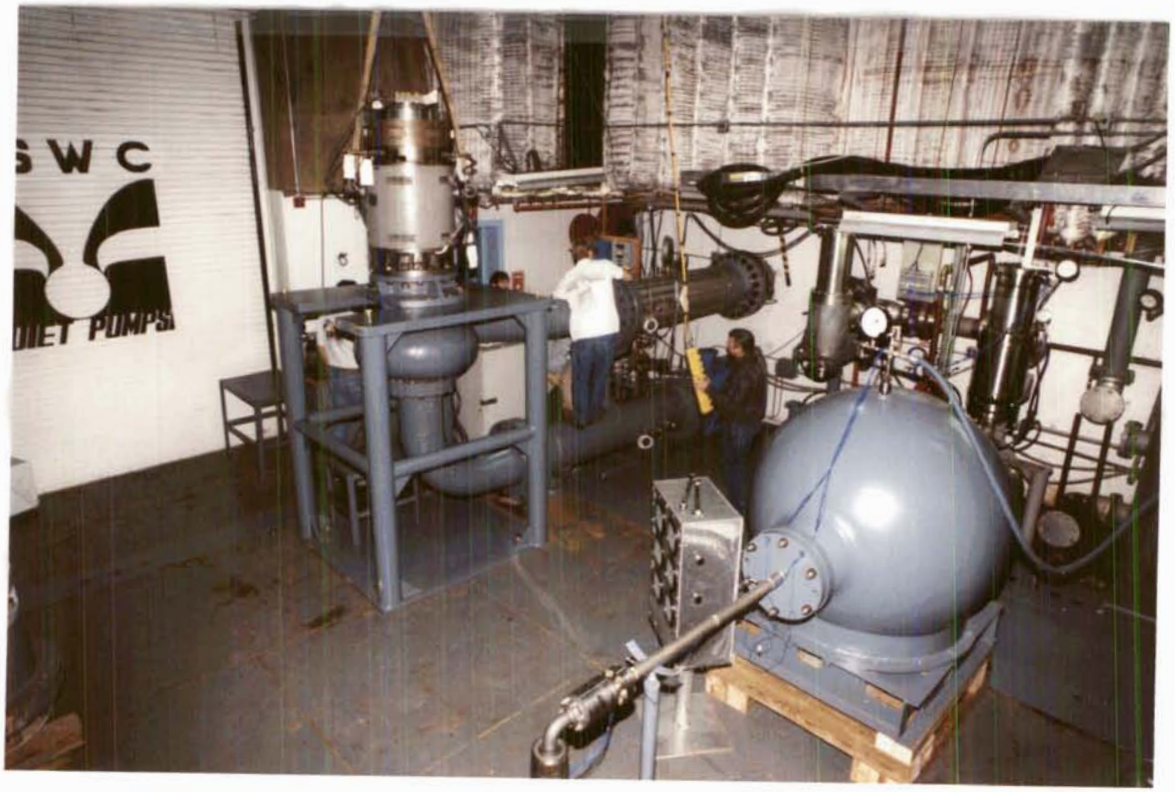


The technologies for which extensive R&D are conducted include superconductive wire and magnets, cryogenic systems, helium refrigerators and compressors, current collectors, transmission lines, electric switchgear, and controls that are required for applications of superconductivity. Other applications for these technologies are also of interest.

Successful development and application of superconductive technology can enhance the operational capability of the Navy and Marines. The magnetic minesweeping system will greatly assist in clearing mine fields,



NSWC MACHINERY ACOUSTIC SILENCING LABORATORY (ANNAPOLIS)



NSWC
MACHINERY ACOUSTIC SILENCING LABORATORY
(Annapolis, MD)

SUBMARINE FLUID DYNAMICS FACILITY

A world class facility that permits full-scale acoustic and operational evaluations of submarine and surface ship fluid system components.

SIGNIFICANT CAPABILITIES - long time duration, full scale testing of piping system components at real pressures and flows without the influence of test system background noise (alternative - use operational submarines)

FULLY UTILIZED - in demand by Navy sponsors, ship designers and builders, and private industry.

FUTURE DEMAND - support current and planned submarine design and development, address changing submarine and surface ship missions (special forces support, shallow water operations) and evaluate the introduction of new materials (composites)

NSWCCD, Annapolis Detachment

the central control panel to facilitate communications and assure test data correlation with system fluid dynamic conditions.

Since 1969, the Submarine Fluid Dynamics Facility has been used to perform noise and vibration tests and evaluations of air and water system components for shipboard applications. This work has resulted in the development of numerous quiet fluid system components.

Data Acquisition and Analysis

An integral part of the facility is the data acquisition and analysis center. Instrumentation is provided to obtain up to 14 channels of noise and vibration data simultaneously and perform narrowband, one-third octave band, and transient spectral analyses from 0 to 50,000 Hertz. The data system is designed to obtain structureborne and airborne noise measurements as well as fluidborne sound pressure levels.

A 486/66 computer controls the system and provides on-line data analysis, hard copy printouts, analog signal storage

by a multi-track precision magnetic tape recorder and digital storage on high capacity disks. Suitable signal conditioners, filters, and amplifiers included in the sytem assure that data is accurate and only represents the noise characteristics of the component being tested.

The Submarine Fluid Dynamics Facility is unique in that its services and capabilities are available to qualified vendors for conducting tests and evaluations of proposed shipboard fluid system components. The facility is certified by the Naval Engineering Facilities Command for conformance with the current "System Certification Procedure and Criteria Manual for Deep Submergence Systems" (NAVMAT P-0290).

Specifications of the Submarine Fluid Dynamics Facility

Air System		
Maximum Flow Rate	35,000	scfm
Maximum Pressure	4,500	psig
Storage Capacity	960	cu. ft
Maximum Test Item	4	inches*
Water System		
Maximum Flow Rate	3,500	gpm
Maximum Pressure	1,000	psig
Storage Capacity	56,000	gallons
Maximum Test Item	8	inches*
Data Acquisition and Analysis		
Measurements	structureborne, airborne, and fluidborne noise	
No. Data Channels	14	
Analysis Bandwidths	narrowband, 1/3-octave band, and transient	
Frequency Range	0 to 50,000 Hz	

** Larger sizes can be tested with modifications.*

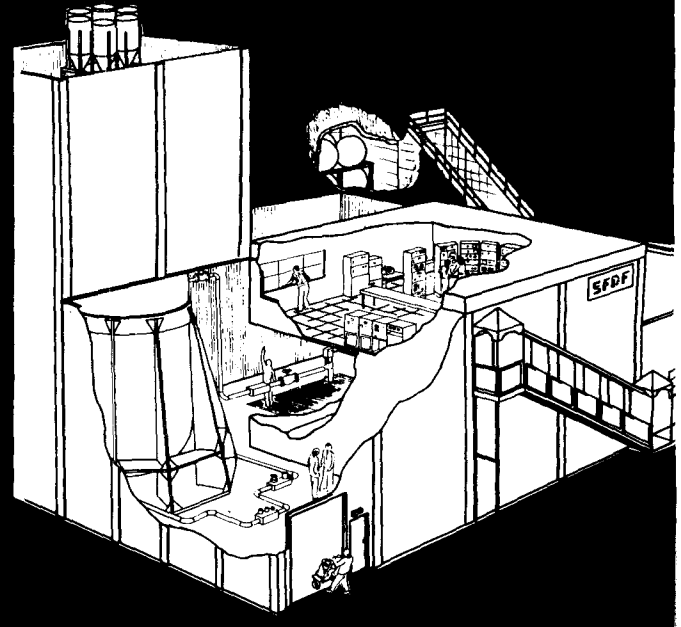
Interested vendors should contact the
Fluid Systems Acoustics Branch
Carderock Division, Naval Surface Warfare Center
Annapolis Detachment
3A Leggett Circle
Annapolis, Maryland 21402-5067

Approved for public release October 1993; distribution unlimited.

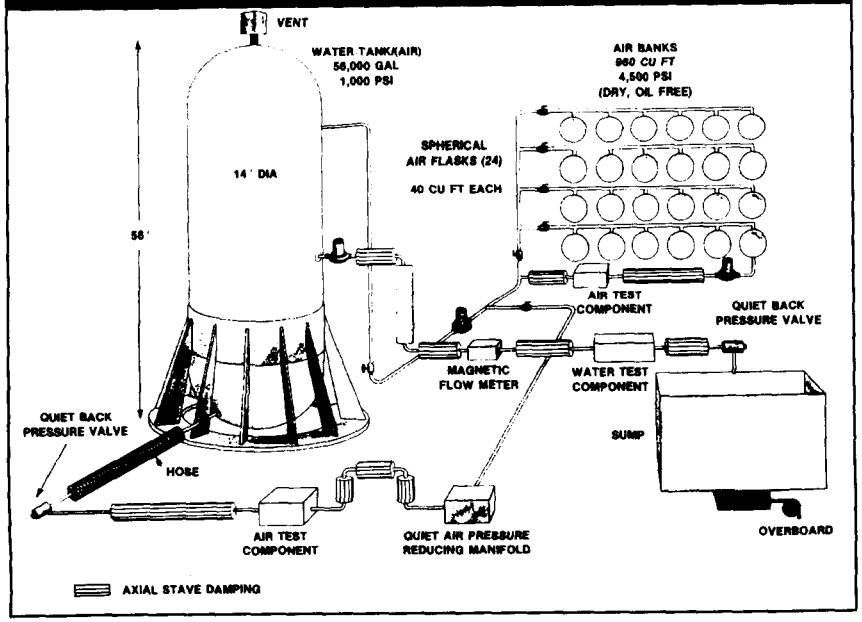
CDR L.R. Walker, USN

Naval Surface Warfare Center
Carderock Division
Annapolis Detachment

Submarine Fluid Dynamics Facility



Subm rine Fluid Dynamics Facility



The Submarine Fluid Dynamics Facility at the Annapolis Detachment of the Carderock Division, Naval Surface Warfare Center, is maintained and operated by the Fluid Systems Acoustics Branch in the Machinery Silencing Department. The facility is designed to produce air and water fluid dynamic conditions (flow rate, pressure, temperature, etc.) similar to actual shipboard air and water machinery systems. The facility provides a test-bed for mechanical and acoustic investigations of prototype Navy valves, manifolds, and other air and water components for shipboard use, and is also used extensively to evaluate and qualify components that are designed and manufactured by commercial industry and proposed for shipboard applications. Tests are conducted in accordance with designated military noise and vibration specifications.

The development of quiet components for air and water shipboard systems is required as part of the Navy's ongoing ship silencing efforts to reduce the structureborne and radiated noise levels of surface ships and submarines. Noise levels generated by air and water system components contribute to the overall radiated noise signature of the ship and directly affect mission performance. Not only is a noisy ship more easily detected, the noise generated by the ship itself hinders its ability to detect others.

Quiet High Pressure Air Test Facility

The air system provides dry, oil-free air at flow rates to 35,000 scfm and pressures to 4500 psig for evaluating the mechanical and acoustic performance of prototype or proposed shipboard system components. Air is stored in 24 high pressure HY-80 spheres located in an underground bunker for safety purposes. The total air capacity is 960 cubic feet, which allows endurance as well as steady-state and transient flow tests. The endurance tests are performed to study icing potential and long term regulation characteristics of a particular air system component. The air spheres, interconnecting piping, and control valves are arranged so that any or all of the spheres can be used to achieve required flow conditions for a test.

State-of-the-art noise reduction methods are applied to the facility's piping system and control valves to reduce flow induced vibrations and thus minimize background noise. Ambient sound pressure levels as low as 30 Adb have been observed.

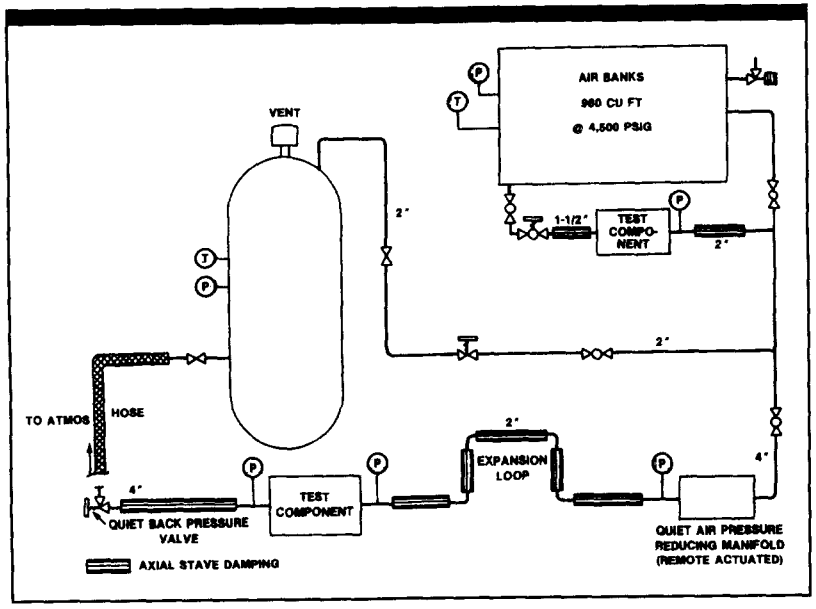
Quiet Water Test Facility

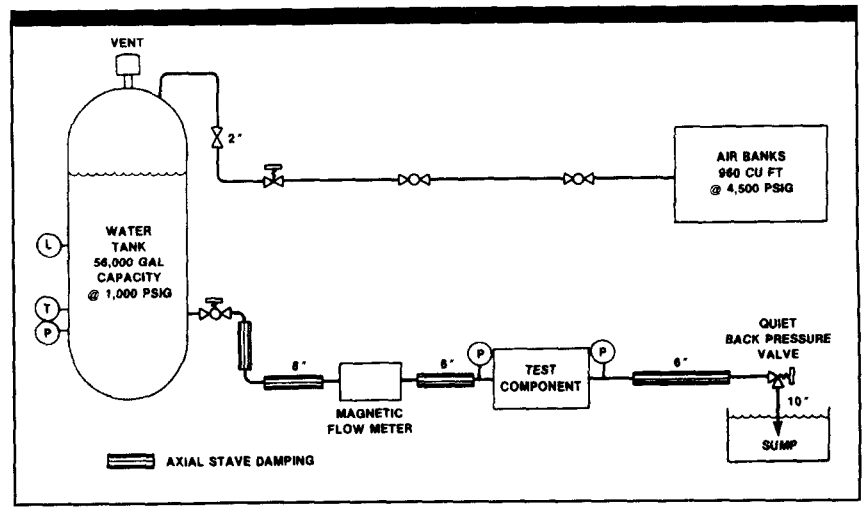
The water section provides water flow rates to 3500 gpm and pressures to 1000 psi. This fluid dynamic capability allows simulation of actual shipboard water system conditions. The water is stored in a 56,000 gallon pressure vessel constructed of HY-80 steel and rated at 1000 psig. A single test station is provided to conduct tests and evaluations of water system components. Components up to eight inches can be routinely installed and tested. Special provisions are made to accommodate larger test items.

Most system fluid flow conditions are controlled remotely from a central control panel. Flow rate is controlled by remotely operated valves, while the control panel provides monitors and displays for system flow rate(s), pressure, and temperature. Data acquisition and analysis is located near

(Left)
Test configuration for components in the Quiet High Pressure Air Test Facility

(Right)
Test configuration for components in the Quiet Water Test Facility





MAGNETIC FIELDS LABORATORY
ANNAPOLIS, DM
NSWC, CARDEROCK DIVISION

TECHNOLOGY

- STEALTH
- ELECTROMAGNETIC SIGNATURE REDUCTION/SHIPS AND SUBMARINES

MILITARY VALUE

- REDUCED VULNERABILITY TO MINES
- SUPPORTS MULTIPLE JOINT MISSION AREAS
  - LITTORAL WARFARE
  - SURVEILLANCE
  - READINESS/MAINTAIN FLEET ASSETS

FACILITY

- UNIQUE
- HIGH COST TO REPLACE/RELOCATE

PROGRAMS/FUTURE PROSPECTS

- $50M IN FUNDS PLANNED THROUGH FISCAL YEAR 1999
- OVER 60% OF FUNDS TO PRIVATE SECTOR

PRODUCTS

- SHIP AND SUBMARINE STEALTH DESIGN
- IMPROVED MINESWEEPER EQUIPMENT

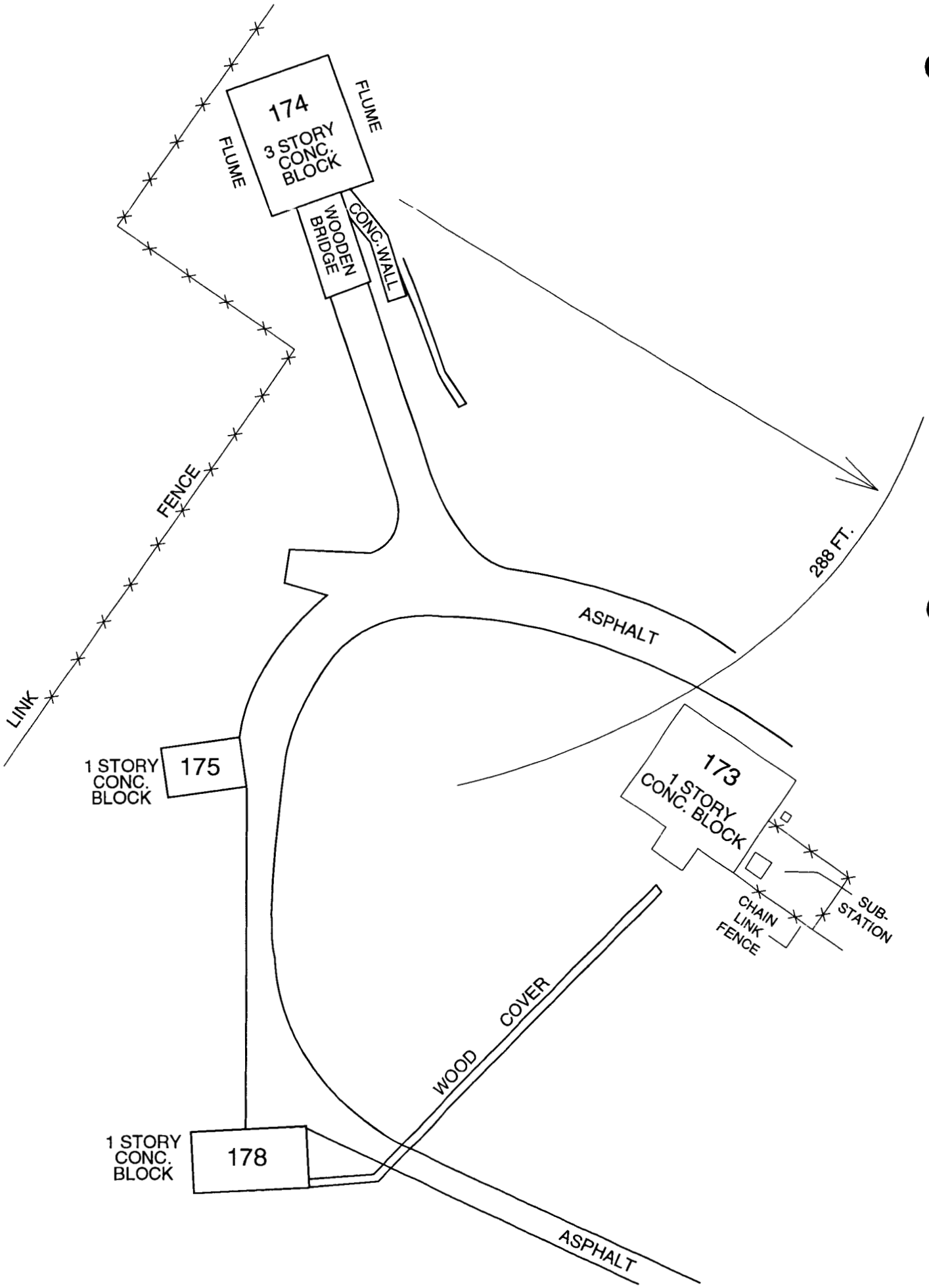
MISSION

DEVELOP THE NECESSARY METHODS, PROCEDURES, SOFTWARE, AND HARDWARE FOR REDUCING SHIP ELECTROMAGNETIC FIELD SIGNATURES TO ACCEPTABLE LEVELS. THE TECHNOLOGY DEVELOPED APPLIES TO SURFACE SHIPS, MINESWEEPERS, SUBMARINES, AND MAGNETIC SILENCING FACILITIES.

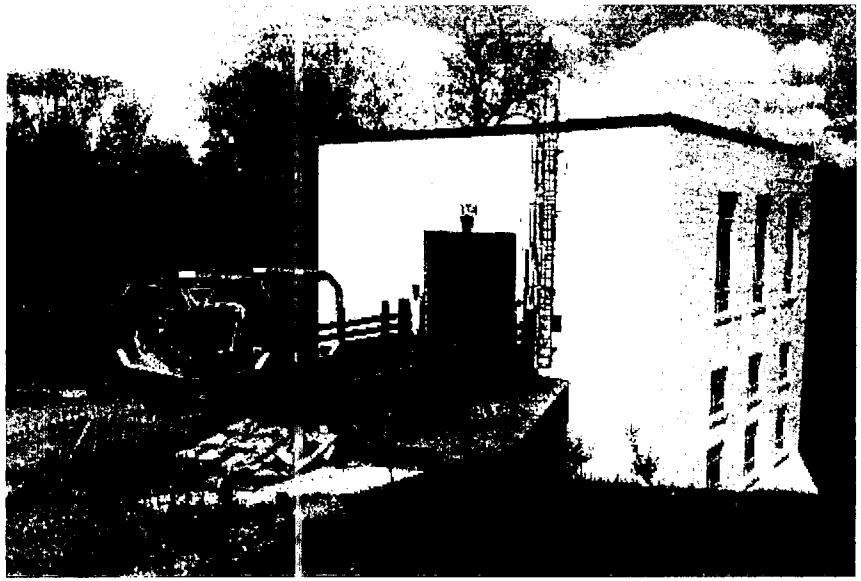
EM MAGNETIC SIGNATURE AND SILENCING AT THE NAVAL SURFACE WARFARE CENTER CARDEROCK DIVISION

THE CARDEROCK DIVISION OF THE NAVAL SURFACE WARFARE CENTER IS THE NAVY'S CENTER OF EXCELLENCE IN SIGNATURE AND SILENCING. THERE ARE COMPLEMENTARY FACILITIES AT THE ANNAPOLIS AND WHITE OAK SITES. AS A RESULT OF BRAC 95 DELIBERATIONS, BOTH SITES ARE RECOMMENDED FOR CLOSURE. THE ANNAPOLIS SITE HAS A FULL-SCALE ITEM TEST FACILITY AND IS CURRENTLY UPGRADING ITS CAPABILITY TO TEST LARGE MAGNETIC MODELS. THE MAGNETIC SILENCING COMPLEX AT WHITE OAK CONSISTS OF THREE COMPLEMENTARY MAGNETIC TEST FACILITIES. THE ANNAPOLIS AND THE WHITE OAK TEST FACILITIES ARE USED TO CONDUCT MAGNETIC RESEARCH IN THE AREAS OF MAGNETIC SILENCING, MAGNETIC SENSOR DEVELOPMENT AND WEAPONS DEVELOPMENT. THE RESEARCH AT BOTH SITES IS A CRITICAL PART OF THE NEWLY STRUCTURED DOD STRATEGY FOR RESTRICTED CONFLICTS IN LITTORAL WATERS.

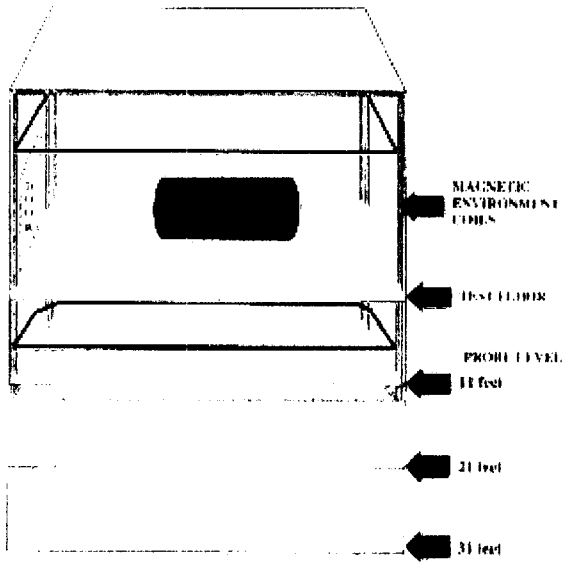
MAGNETIC FIELDS LABORATORY SITE PLAN



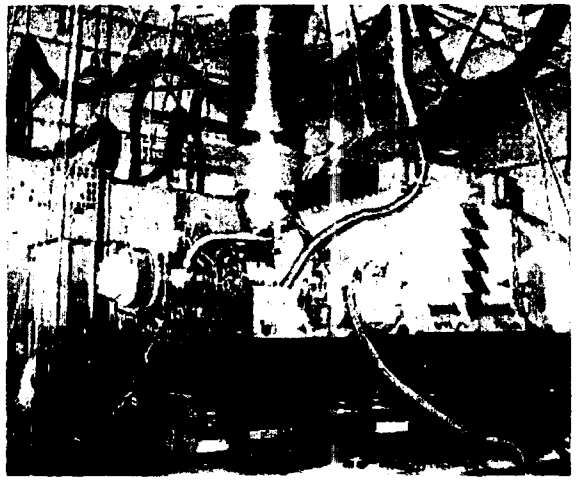
Magnetic Fields Laboratory



Magnetic Fields Measurement Building



Internal Representation of
Measurement Building

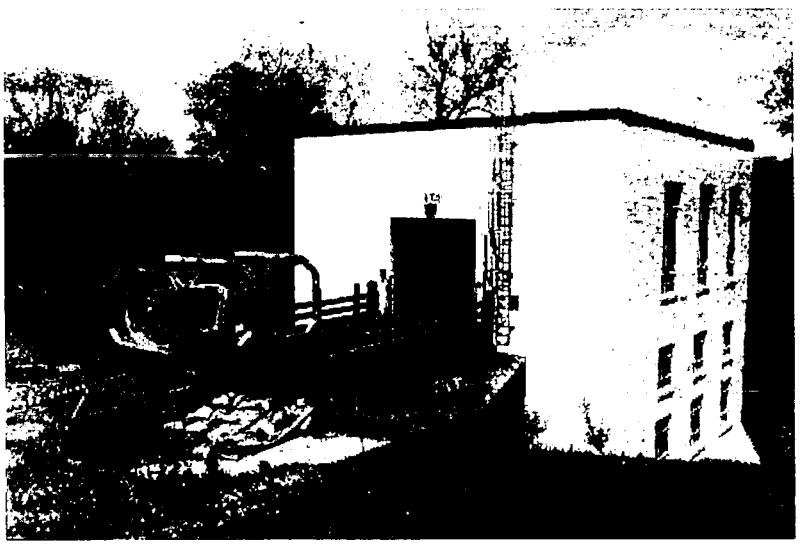


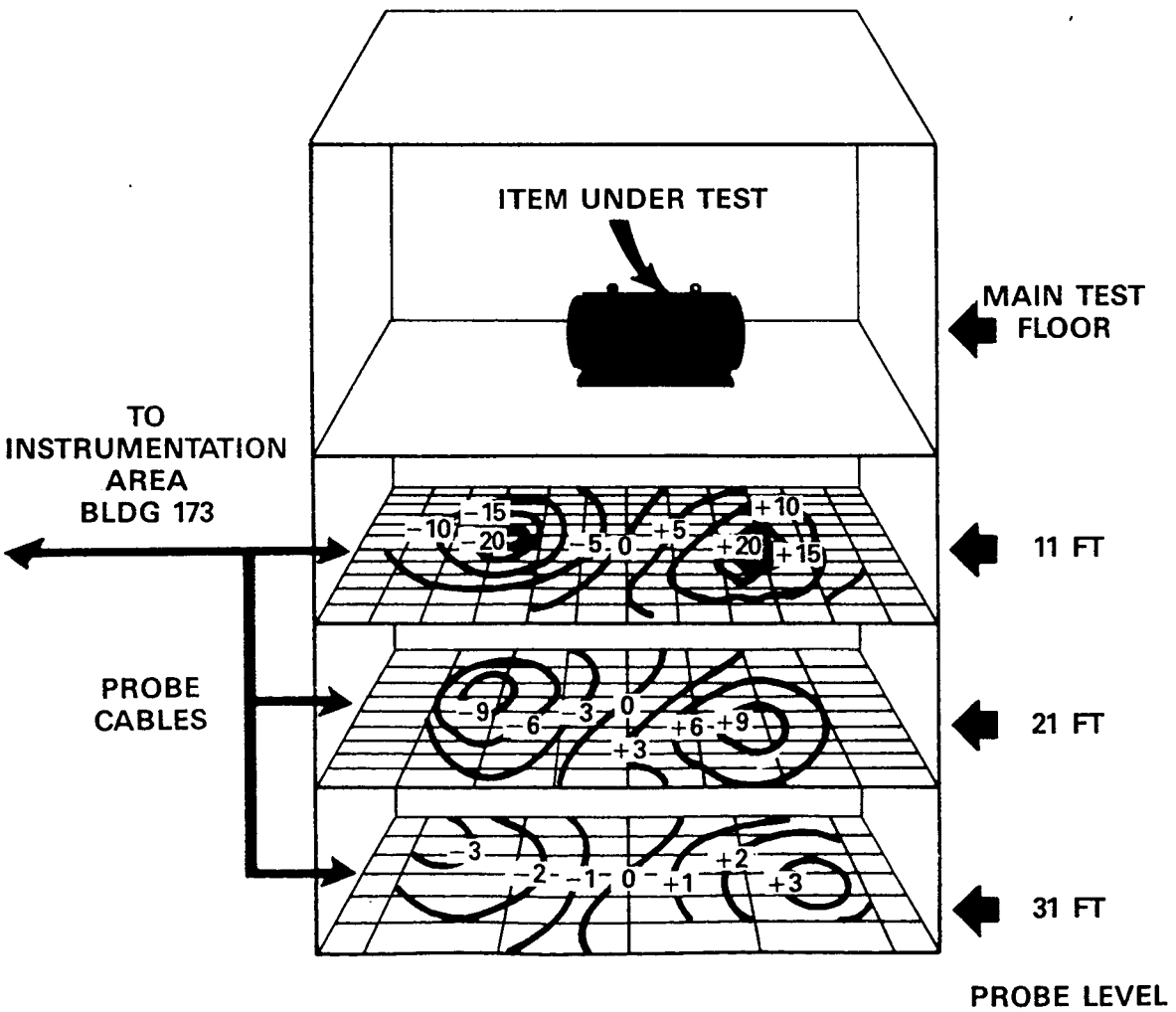
Minesweep Generator Stray
Magnetic Field Measurements

Data Acquisition and Analysis Room,
Control Building

Sensors and Magnetometers
Measurement Building Lower Levels

MAGNETIC FIELDS LABORATORY TEST BUILDING





Magnetic Fields Laboratory

CAPABILITIES

- Supports submarine and surface ship programs focused on the reduction of vulnerability to mines and hostile detection systems.
- Constructed entirely of nonmagnetic materials and physically located in a low noise environment.
- Only facility in the United States that provides accurate measurement of magnetic field signatures beneath full-size operating electrical machinery.
- Powering and loading capabilities include rectified power sources from 200A to 2500A, a 1200A motor starter/controller, a 5000A load bank, three 900A water rheostats, and two water brake dynamometers.
- Capable of simulating actual shipboard machinery environments over the 50 ft. long, 42 ft. wide, and 20 ft. high testing area, weighing up to 44 tons.
- Upgrade of facility in progress to include capability of measuring scaled physical models of submarines and surface ships up to 12 ft. long and weighing up to 1,000 pounds.

PROGRAMS & FUNDING

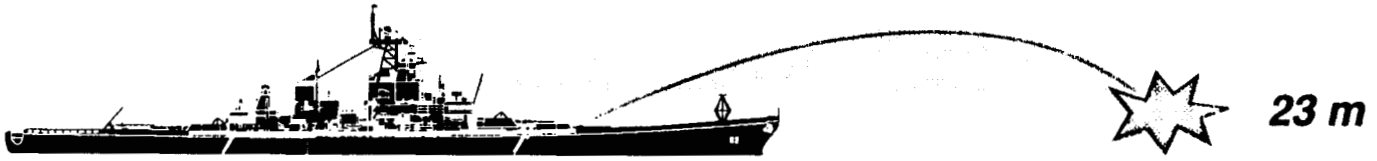
- $50M IN FUNDS PLANNED THROUGH FISCAL YEAR 1999
- PROGRAMS PRIMARILY SUPPORT THE NEW ATTACK AND SEAWOLF SUBMARINES IN ADDITION TO EXPLORATION DEVELOPMENT FOR SURFACE SHIP SILENCING
- FUNDING SOURCES ARE FROM THE NAVY (OFFICE OF NAVAL RESEARCH, NAVAL SEA SYSTEMS COMMAND AND OFFICE OF NAVAL OPERATIONS) IN ADDITION TO PRIVATE FUNDS
- THE WORK IS CARRIED OUT BY THE NAVY, INDUSTRY AND UNIVERSITIES AND INCLUDE INTERNATIONAL EXCHANGE PROGRAMS (UNITED KINGDOM, JAPAN, GERMANY, ETC)
- THE APPROACH TAKEN IN STEALTH DESIGN INCLUDE MEASUREMENTS AT SEA AND IN THE LABORATORY IN ADDITION TO COMPUTER MODELING. LOSS OF LABORATORY MEASUREMENTS WOULD ADD RISK AND HIGH COSTS (MORE SEA TRIALS)

Pulsed Power Systems R & D

- *Primary sponsor is ETC Gun Technology*
- *Fully coordinated under PROJECT RELIANCE, Navy lead*
- *Teaming effort with NSWC Dahlgren and Indian Head*
- *Also supports:*
  Electromagnetic Aircraft Launchers
  Advanced Mine Countermeasures
  Environmental Remediation Efforts
- *2 and 4 MVA prime power sources*
- *8.5 MJ US Army Pulsed Power Module*
- *EMI shielded control and data acquisition*

NAVAL FIRE SUPPORT

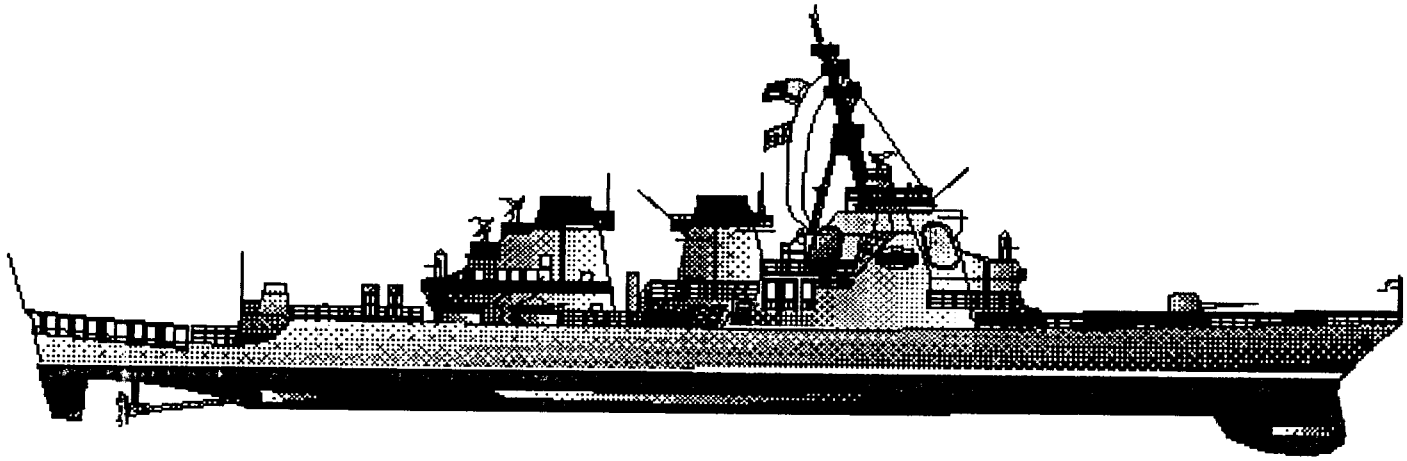
BATTLESHIPS – 16" GUNS

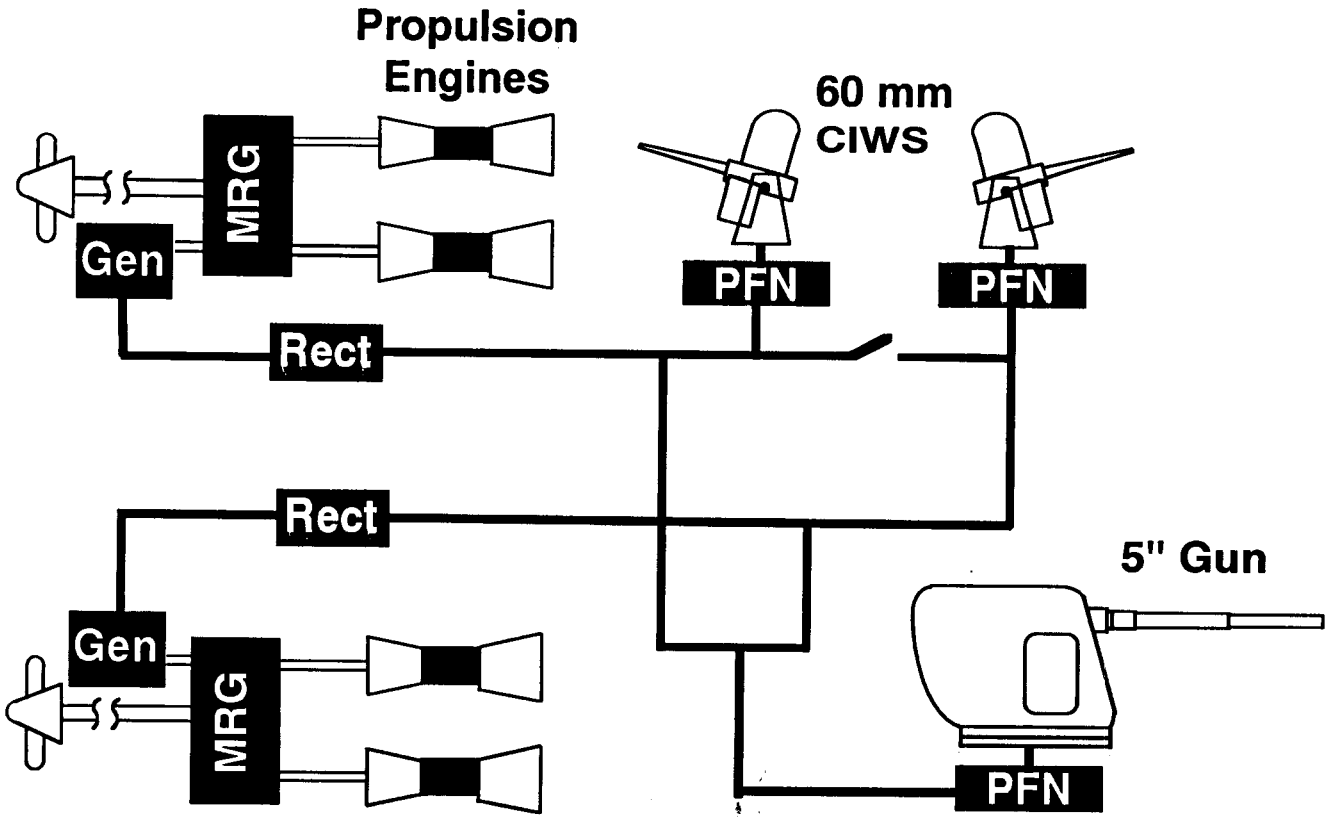


CRUISERS AND DESTROYERS– 5" GUNS

CRUISERS AND DESTROYERS– 5" ETC GUNS

Electric Gun Equipped Surface Combatant

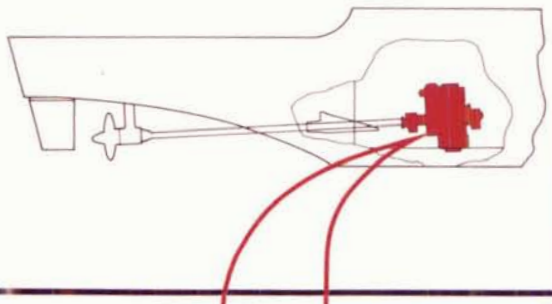




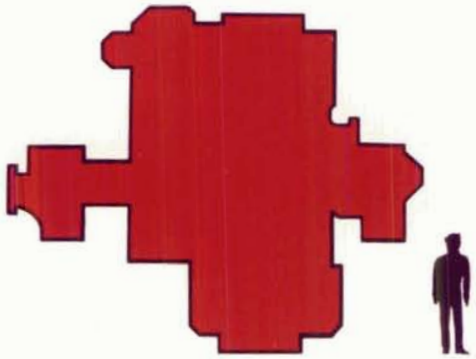
NAVY ELECTRIC PROPULSION

40,000 HP 180 RPM

CONVENTIONAL DESTROYER



CONVENTIONAL AIR-COOLED AC MOTOR



320,000 LBS
20 FT DIAMETER
95% EFFICIENT

PODDED DESTROYER

SUPERCONDUCTIVE DC MOTOR

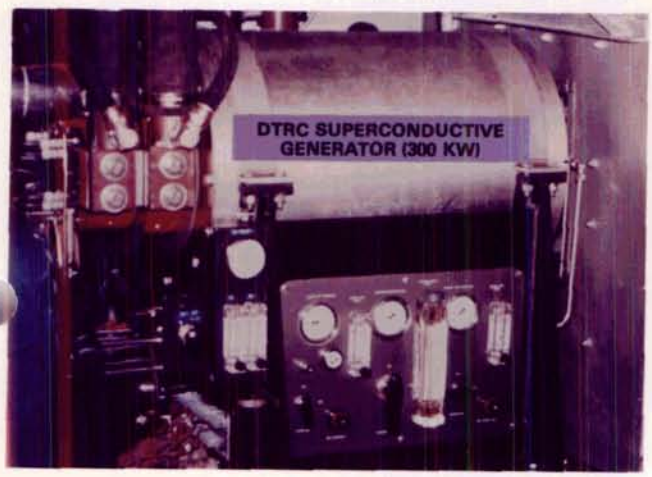
88,000 LBS
6.5 FT DIAMETER
99% EFFICIENT

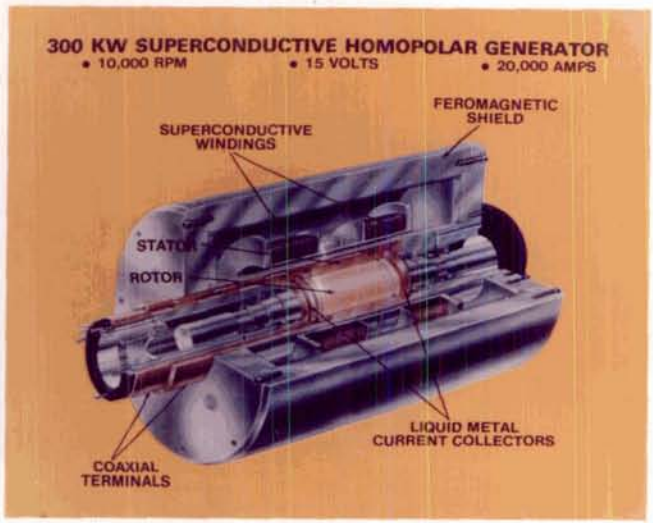
Superconductive electric propulsion makes possible the realization of advanced ship concepts due to its significant increase in power density. This will result in improved ship performance (acoustic signature and energy efficiency) and reduced ship size and cost.

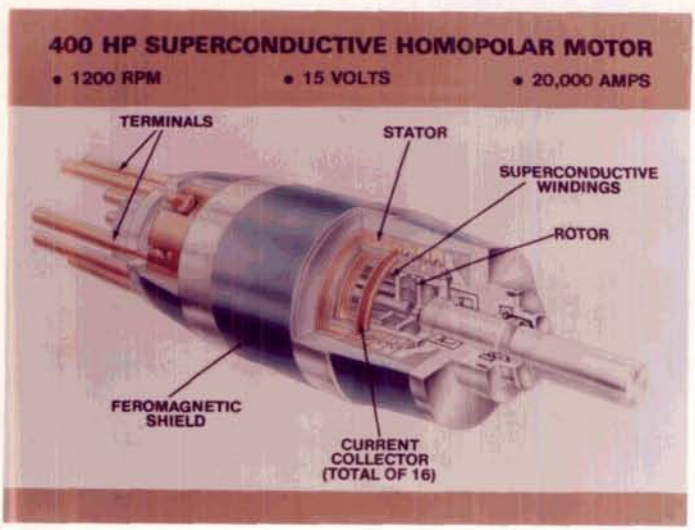
400 HP ELECTRIC DRIVE SYSTEM

Jupiter II underway with electric drive

The David Taylor Research Center, Annapolis, MD., began development of superconductive electric propulsion systems in 1969. The first complete system, consisting of a turbine driven 300 KW superconductive homopolar generator supplying power to a 400 HP superconductive homopolar motor, was constructed in the early 1970's. The system was installed on the test craft Jupiter II. On September 23, 1980 the vessel became the first in history to be propelled by a completely superconductive electric drive. In 1980 there were 12 other at-sea demonstrations. The machines now serve as lab test rigs to explore more advanced concepts in machine design.







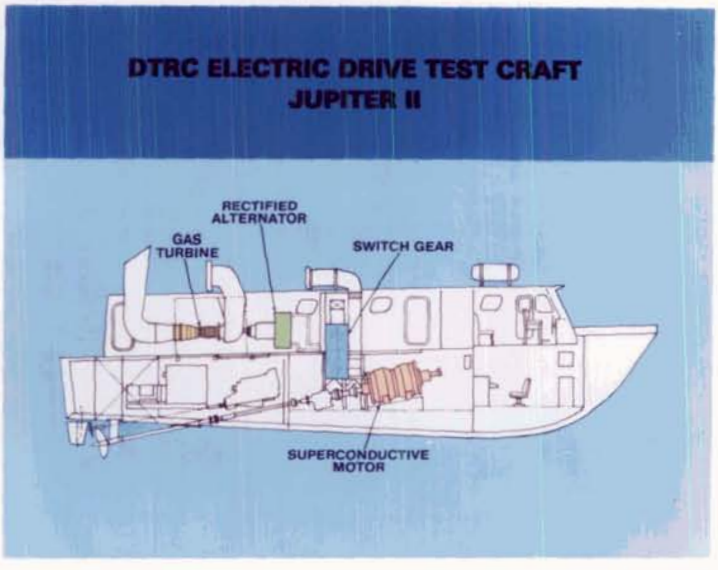
The superconductive motor being installed on Jupiter II

3000 HP ELECTRIC DRIVE SYSTEM

General Electric 3000 HP superconductive motor is installed on Jupiter II. Motor characteristics: 1200 rpm, 100 volts, and 22,500 amps.

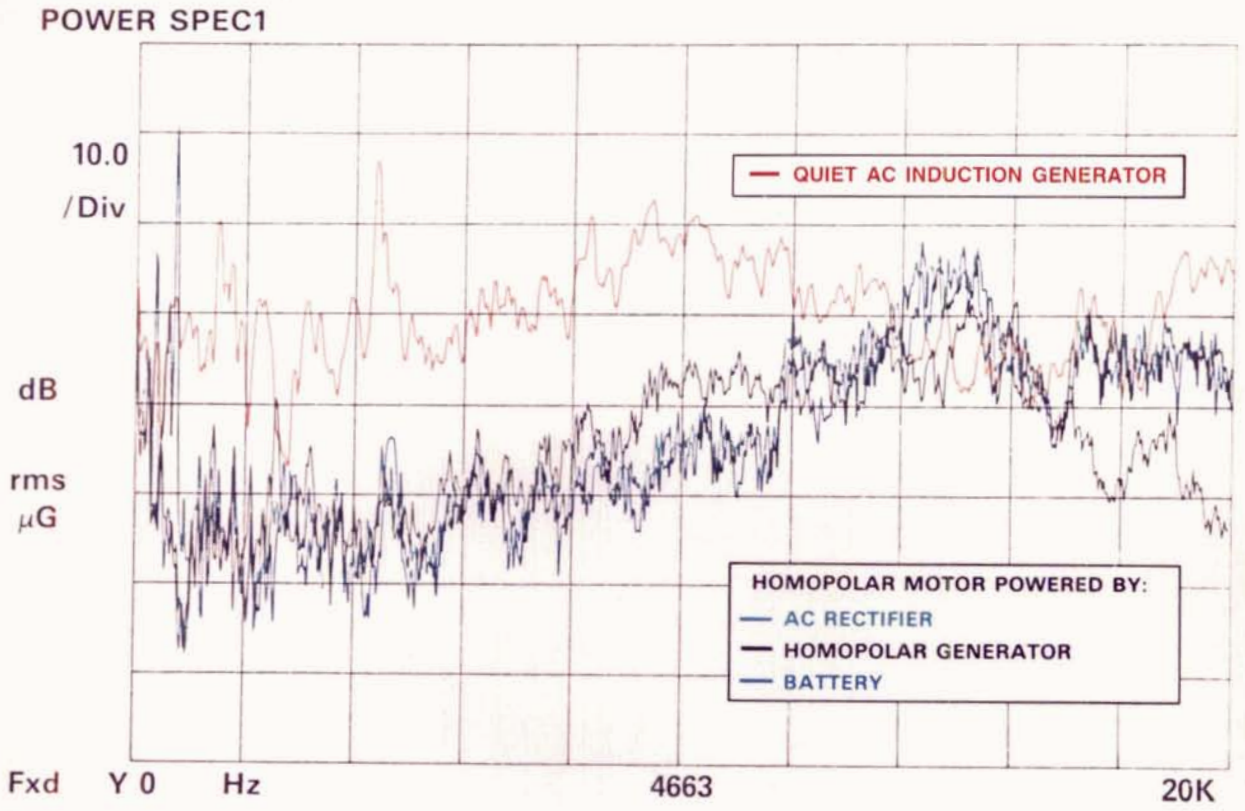
Normally conducting, rectified alternator (built by Garrett Air Research) is installed on Jupiter II. Alternator characteristics: 10,000 rpm, 100 volts, and 22,500 amps.

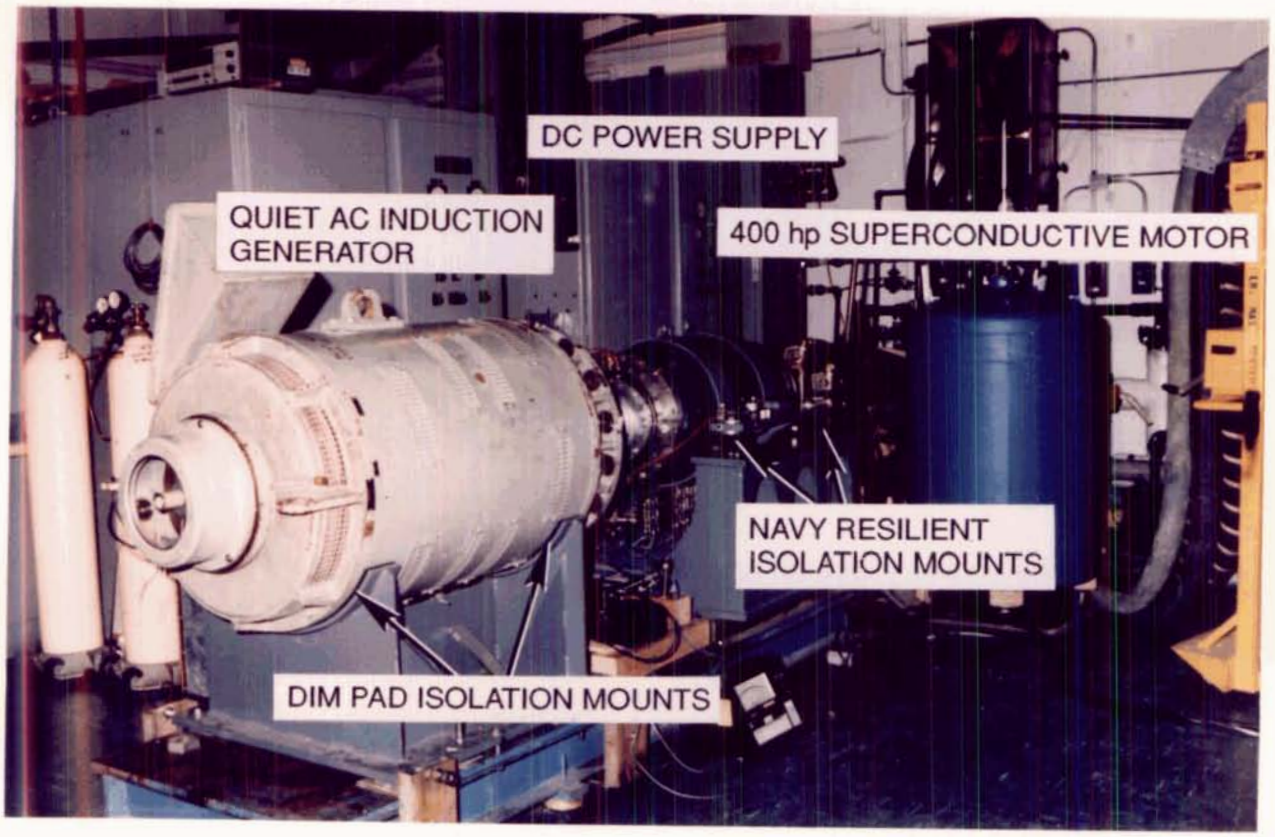
Following the success of the Navy-developed 400 HP superconductive propulsion system, a contractor-built 3000 HP system was installed aboard Jupiter II in 1983. Several at-sea demonstrations were conducted. This system consists of a gas turbine driven rectified alternator supplying power to a 3000 HP superconductive homopolar motor.



Jupiter II with the destroyer, USS DEYO (DD 970)

HOMOPOLAR ACOUSTIC PERFORMANCE

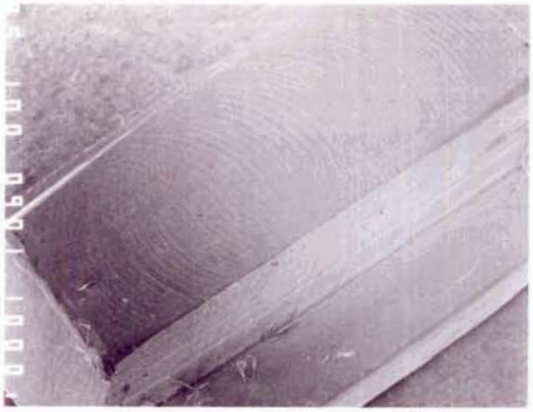




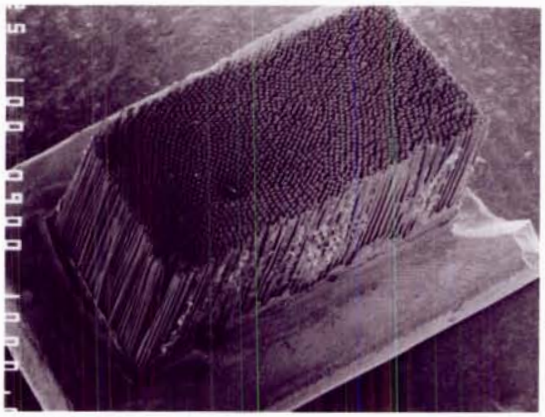
CURRENT COLLECTOR TECHNOLOGY

Fiber Brush Current Collector

Unetched Cu Matrix Nb Fiber



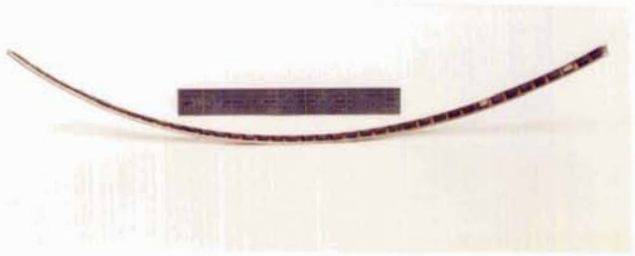
Etched Brush Sample



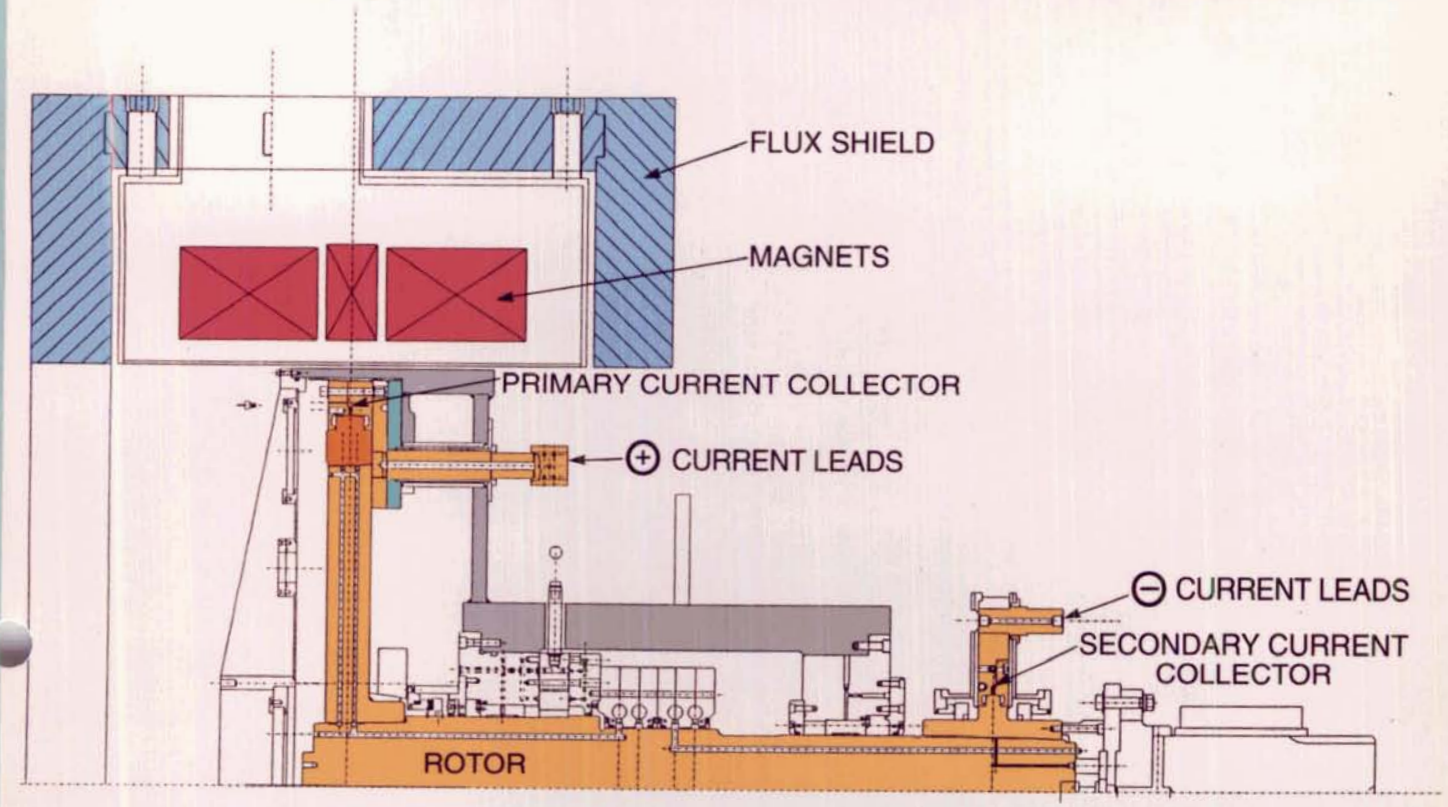
Fiber Brush Current Collector Parameters

Fibers per Brush	2000
Fiber Diameter	.002 in
Material	Niobium Fibers in Copper Matrix
Packing Fraction	75%
Orientation	40 degrees Trailing
Load	130 g/brush

Fiber Brush Current Collector Assembled Into Holder



30 MW MOTOR MODEL TEST RIG



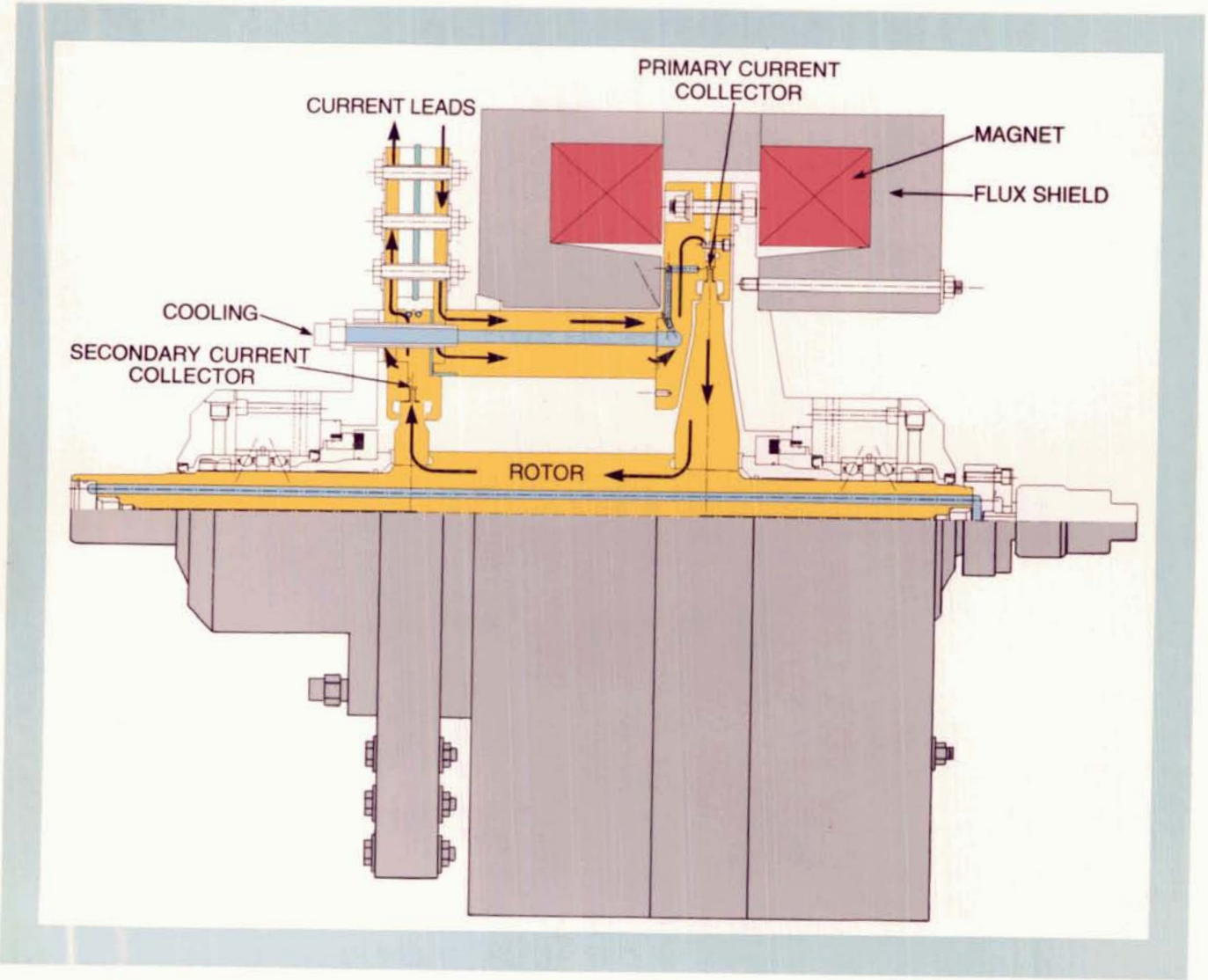
CAPABILITIES:

Speed: 180 rpm

Current: 180 kA

Mag Field: 2.3T

15 MW GENERATOR MODEL TEST RIG



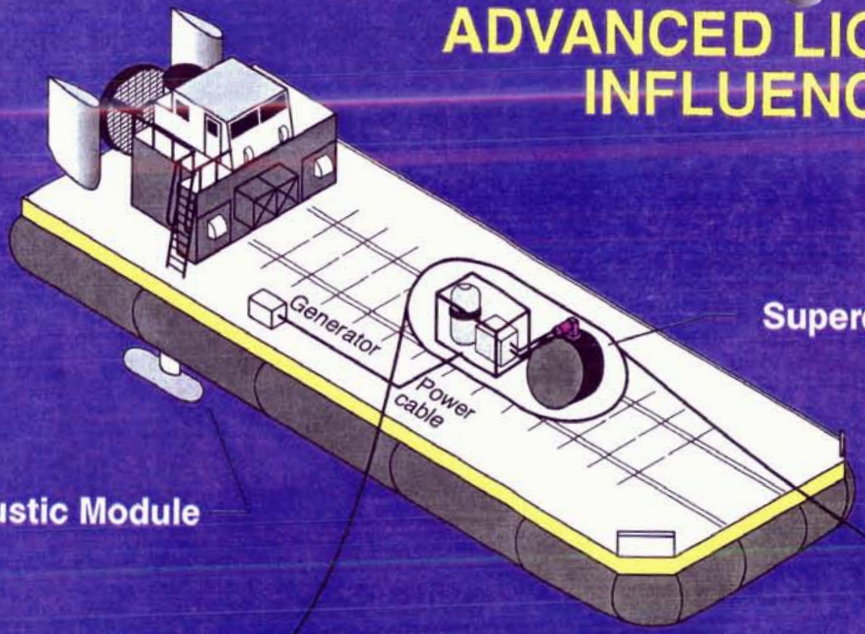
CAPABILITIES:

Speed: 6000 rpm

Current: 90 kA

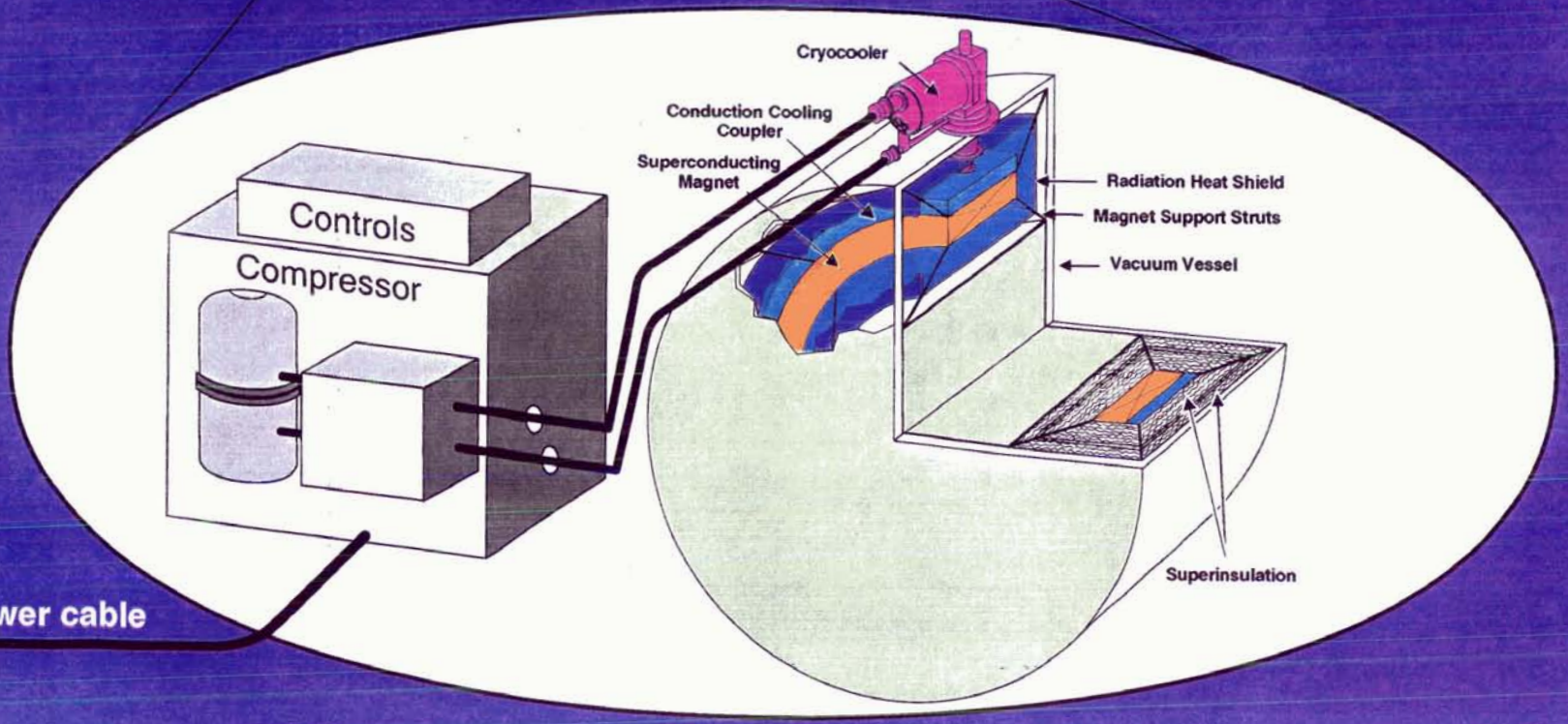
Mag Field: 0.5T

ADVANCED LIGHT WEIGHT MAGNETIC INFLUENCE SWEEP SYSTEM



Superconducting Magnet Module

Acoustic Module

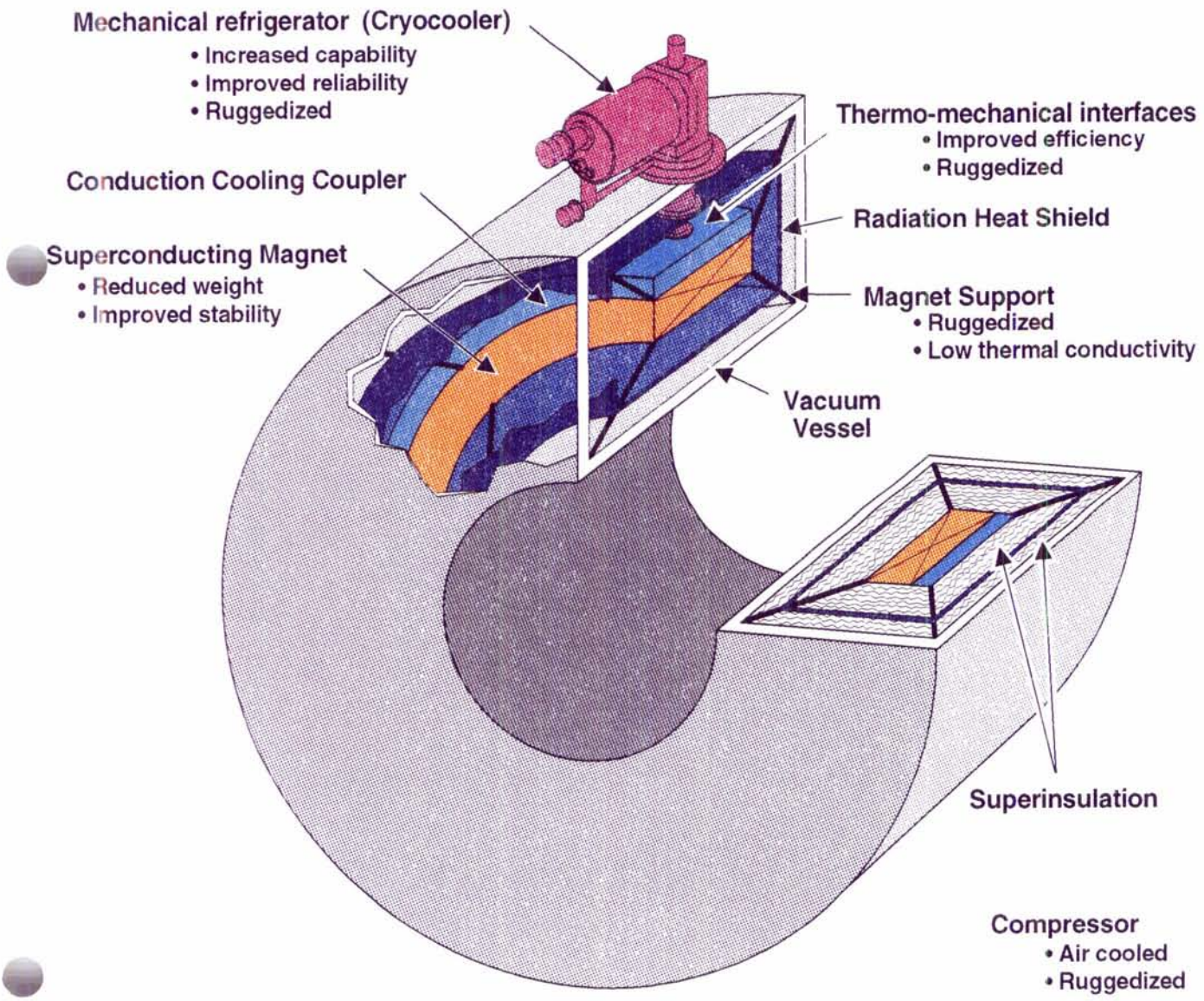


Power cable

Advanced Lightweight Influence Sweep System (ALISS)

GOAL: Demonstrate conductively cooled superconducting technology to provide high speed influence sweep system for over-the-horizon amphibious assault .

Component Development Required for Conductively Cooled, Superconducting Magnet System

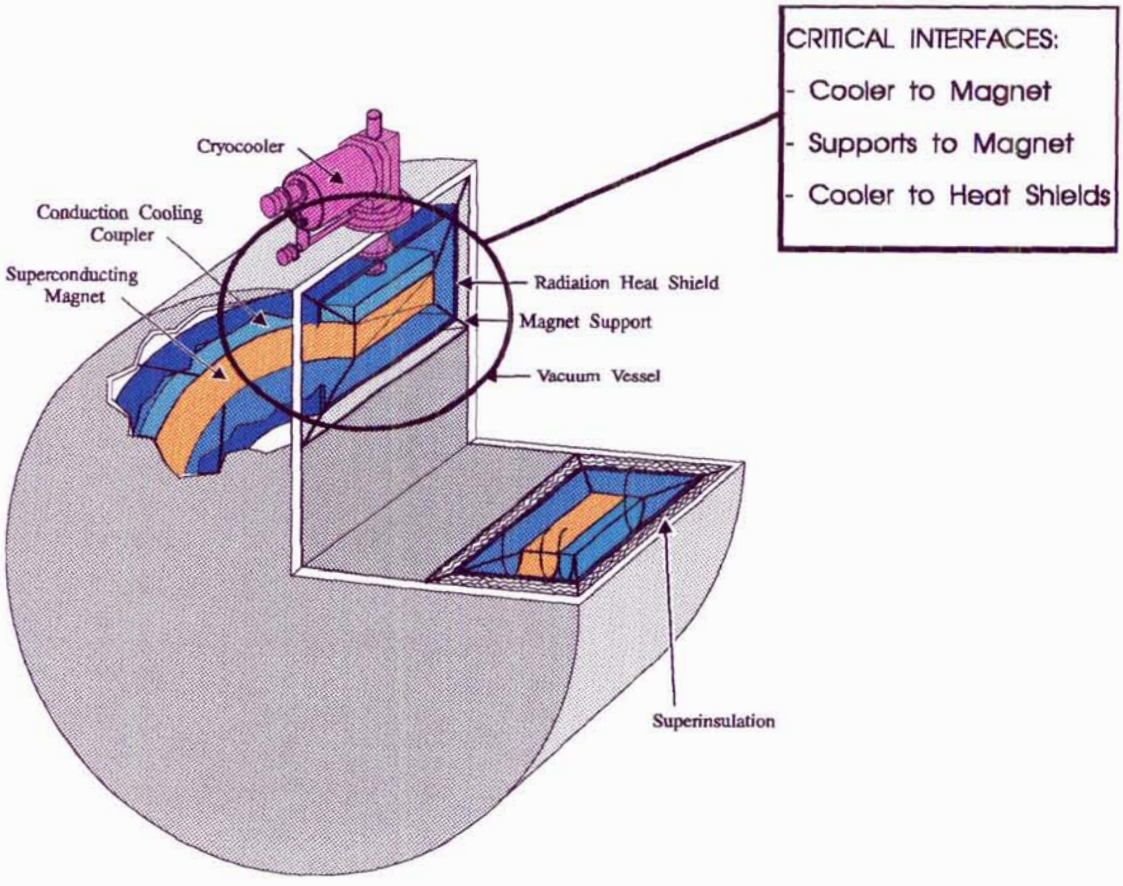


ADVANCED LIGHTWEIGHT INFLUENCE SWEEP SYSTEM (ALISS) THERMAL AND MECHANICAL MAGNET INTERFACES

SUMMARY: Conductively cooled superconducting magnet systems are cooled directly by very low temperature cryogenic refrigerators. In these conductively cooled systems the connections, or interfaces, between for example the superconducting magnet and refrigerator are critically important. If the interfaces do not have very low resistance to the flow of heat, then increased refrigeration capacity is necessary. Therefore, thermally efficient, shock and vibration tolerant thermal and mechanical interfaces are critical for conductively cooled superconducting magnet systems.

TECHNOLOGY DEVELOPMENT:

- Designed and fabricated only full scale interface measurement apparatus in U.S.A.
- Full-scale interface concepts are designed, fabricated, and tested.
- Full scale interface evaluations conducted for industry because of the uniqueness of this apparatus.



THERMAL INTERFACE EVALUATION

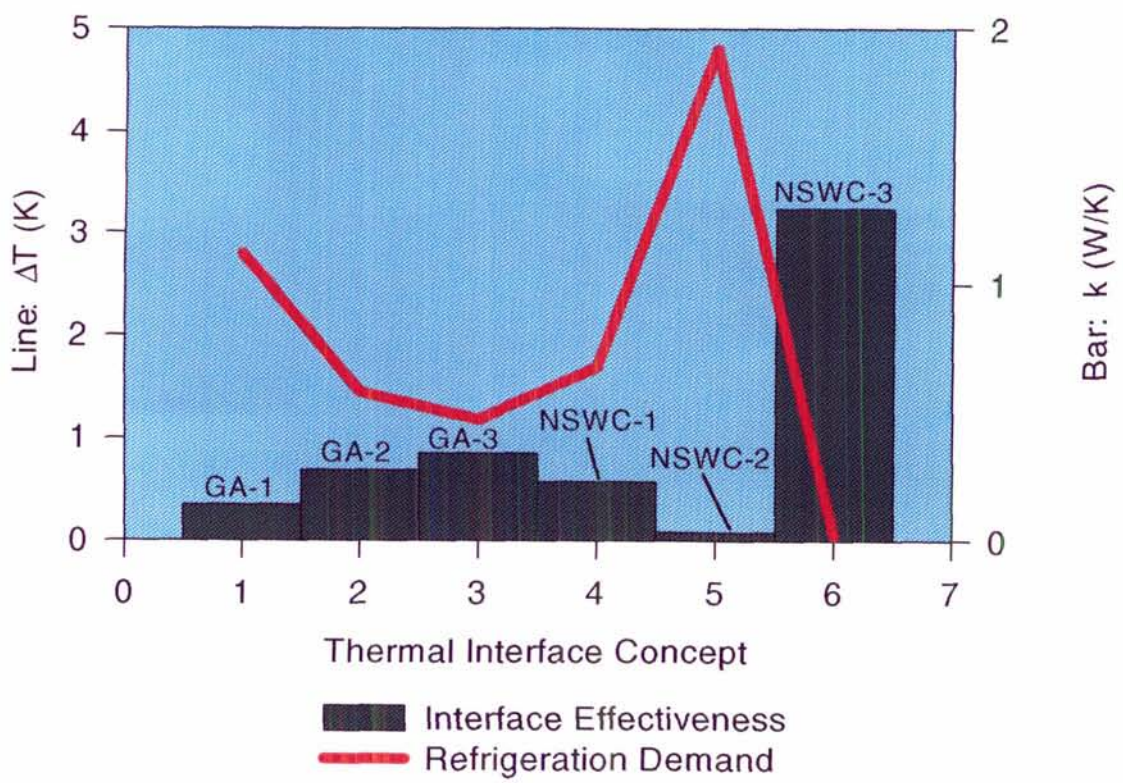
A test apparatus has been designed and fabricated at the Annapolis Detachment, NSWC for evaluating the thermal effectiveness of full-scale ALISS interface concepts. This apparatus has been used to evaluate novel concepts of NSWC and industrial partners. Example results from some of these tests are shown below in Fig. 1. Industry is beginning to use this apparatus because an interface evaluation system like this is not available any where else in the United States.

Industrial Customers:

- General Atomics; Interface concepts for ALISS.
- General Electric; Performance of high temperature superconducting current lead.

Dual Use: Industrial superconducting magnet manufacturers have recognized the need to transition to conductively cooled magnet systems. For example, manufacturers of magnetic resonance imaging systems have already begun to fabricate systems derived in part from ALISS interface technology. Most importantly, new possibilities for using superconducting magnet technology are emerging because of the development conductively cooled magnets

Figure 1. Industry and NSWC Interface Performance



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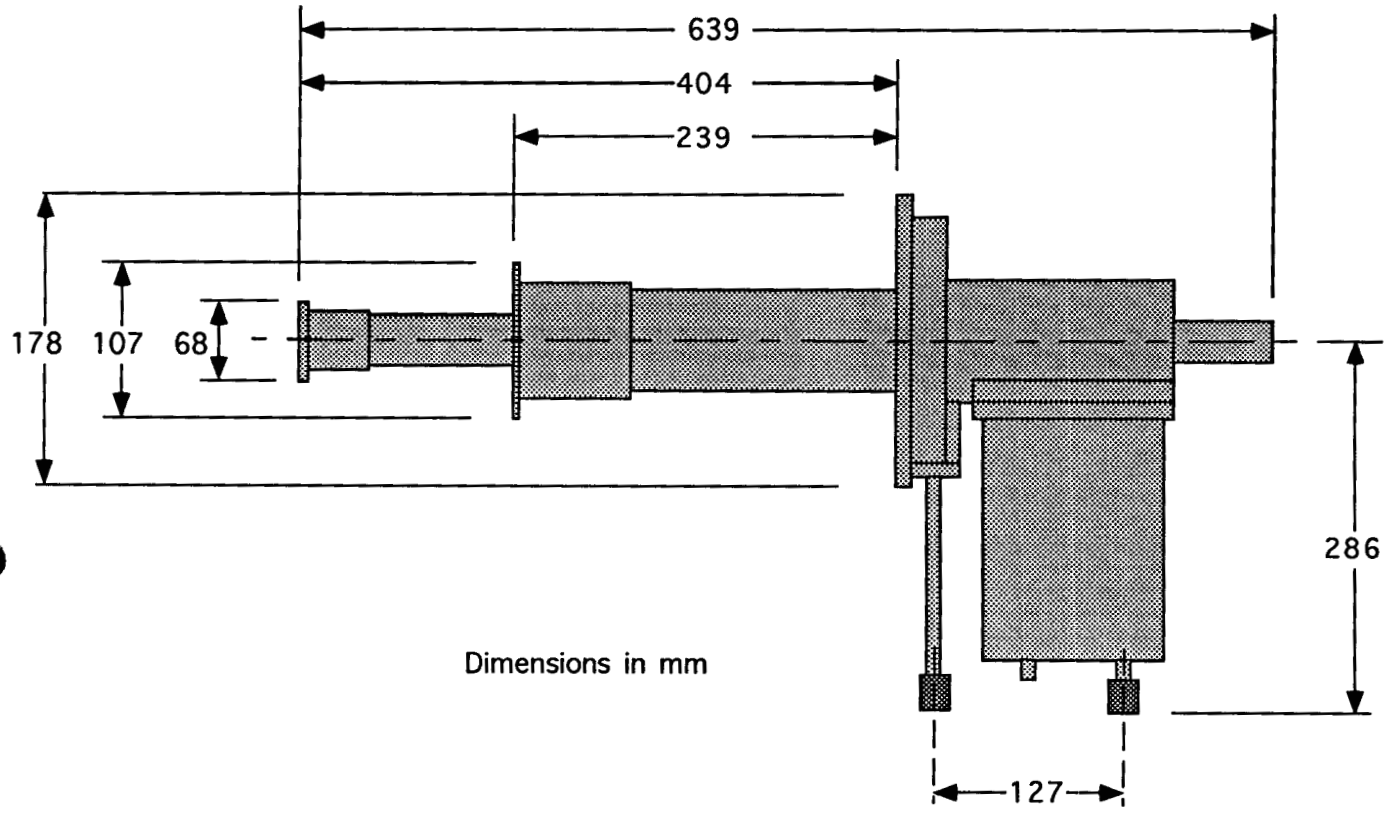
ANNAPLOIS, MD

CRYOGENIC REFRIGERATION

NSWC Developed G-M Cryocooler



Dimensions in mm

- First commercialization of a 4.2K G-M cryocooler modified by NSWC
- Cryocooler utilizes NSWC neodymium regenerator
- First cryogenic cooler to meet mil-spec for shock and vibration after modification by NSWC
- NSWC modified cooler used to demonstrate conductive cooling of a magnet at 4.2 K

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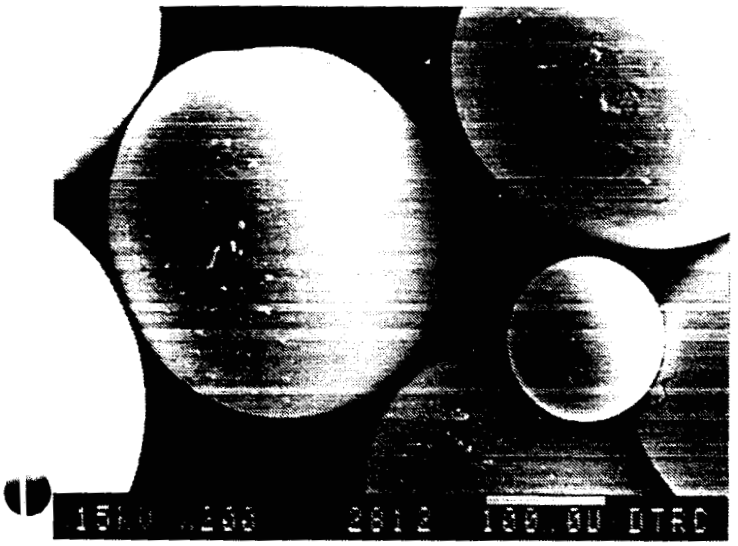
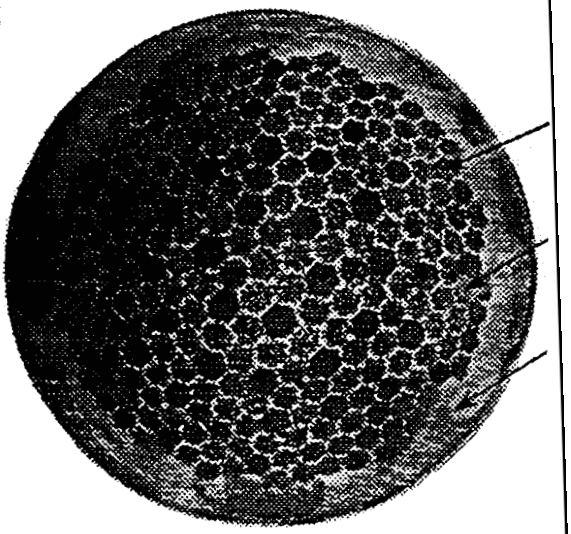
ANNAPOLIS MD

CRYOGENIC REFRIGERATION

LOW TEMPERATURE REGENERATOR GEOMETRIES



SPHERES



PERFORATED PLATE

0.002" RIBBON, 0.002" RIDGE, 0.100" WIDTH

EMBOSSED RIBBON

MAGNETOHYDRODYNAMIC DRIVE (MHD)

PROPELLERLESS PROPULSION

SUMMARY. Magnetohydrodynamic drive was invented in the United States in 1961. MHD is at its essence a water pump or water jet drive. As apposed to a typical industrial pump, an MHD pump takes advantage of the interaction between magnetic fields and electric currents to produce a pumping effect that can propel a submarine or surface ship as shown below. Magnetic fields necessary for MHD are extremely high, and are achievable only by using superconduciting magnets. Because MHD thrusters have no moving parts, MHD has the potential to be an extremely quit drive system without loss of maneuverability or speed. Recently, an MHD program has been initiated that will result in a demonstration of an MHD driven 8.5m long unmanned underwater vehicle. This demonstration will take place in FY97. Finally, a conceptual rendering of a Los Angeles class submarine outfitted with an MHD thruster is shown on the following page.

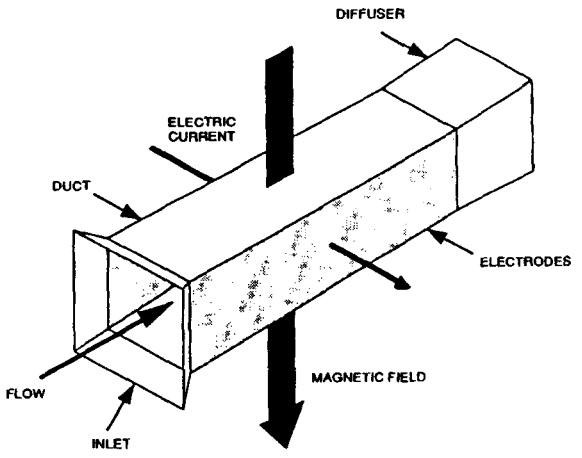


Fig. 1. Basic magnetohydrodynamic drive duct.

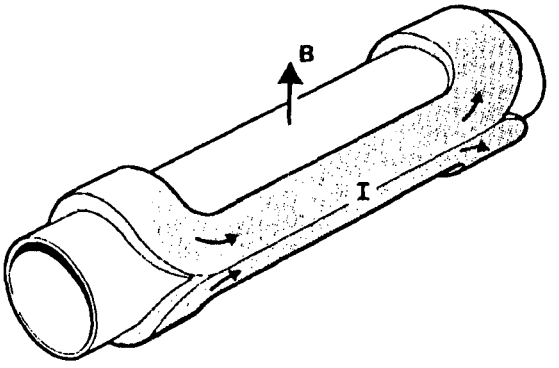
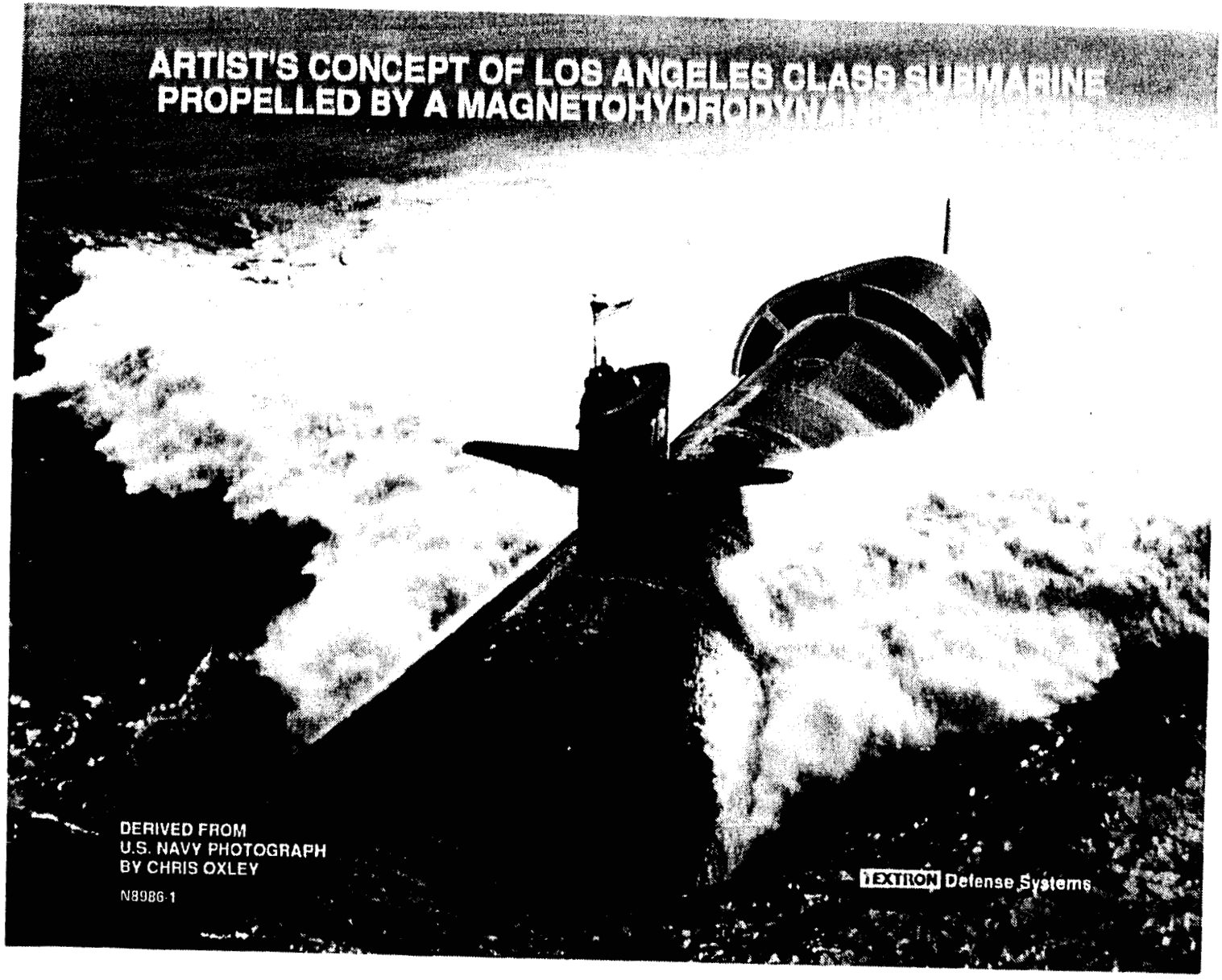
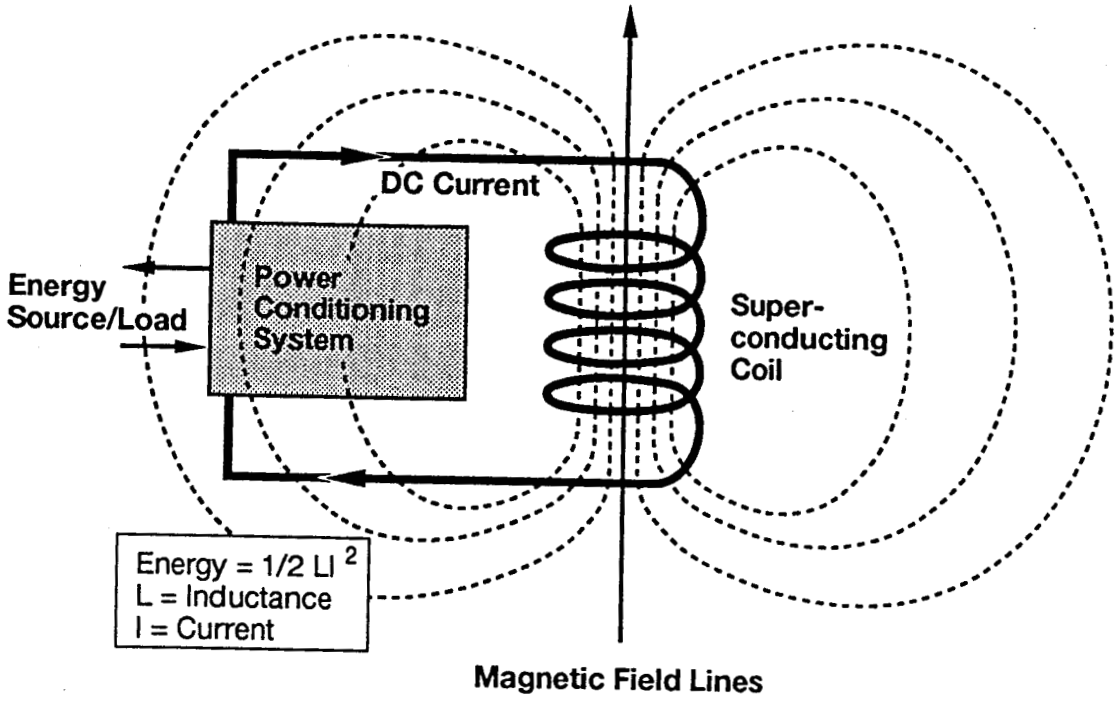


Figure 2. Saddle configuration duct.


ARTIST'S CONCEPT OF LOS ANGELES CLASS SUBMARINE
PROPELLED BY A MAGNETOHYDRODYN
DERIVED FROM
U.S. NAVY PHOTOGRAPH
BY CHRIS OXLEY
N8986-1
TEXTRON Defense Systems

SUPERCONDUCTIVE MAGNETIC ENERGY STORAGE (SMES)



SMES Principles of Operation

SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES) ENERGY TRANSFER BETWEEN SUPERCONDUCTING MAGNETS

SUMMARY. The U.S. Navy has developed an efficient means to transfer magnetic stored energy from one superconducting magnet to another as shown in Figs. 1 and 2 below. Fleet systems and procedures benefiting from this work include superconducting electric drive and mine sweeping. Commercial industries benefiting from SMES technology include for example electrical utilities for load leveling and diurnal storage, and specialty space applications for high precision magnetic balancing. SMES technology is a rapidly growing and maturing technology, and the Navy will continue to be a world leading active partner.

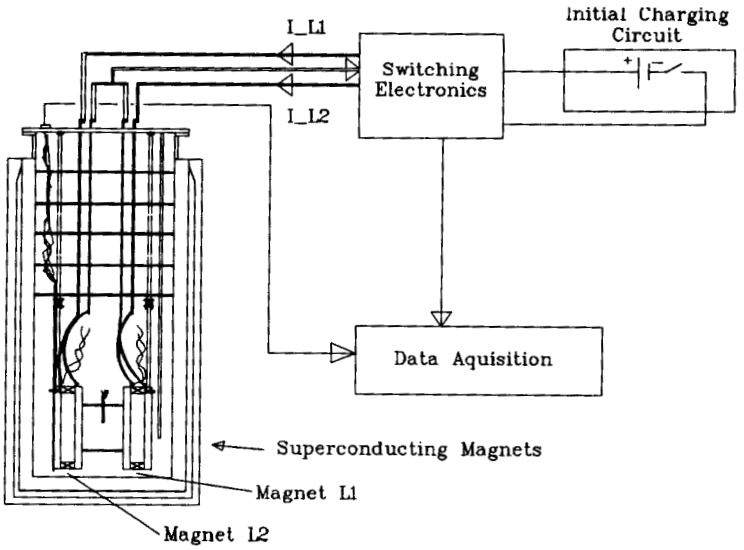


Figure 1. Superconducting magnetic energy transfer control circuitry and superconducting magnets.

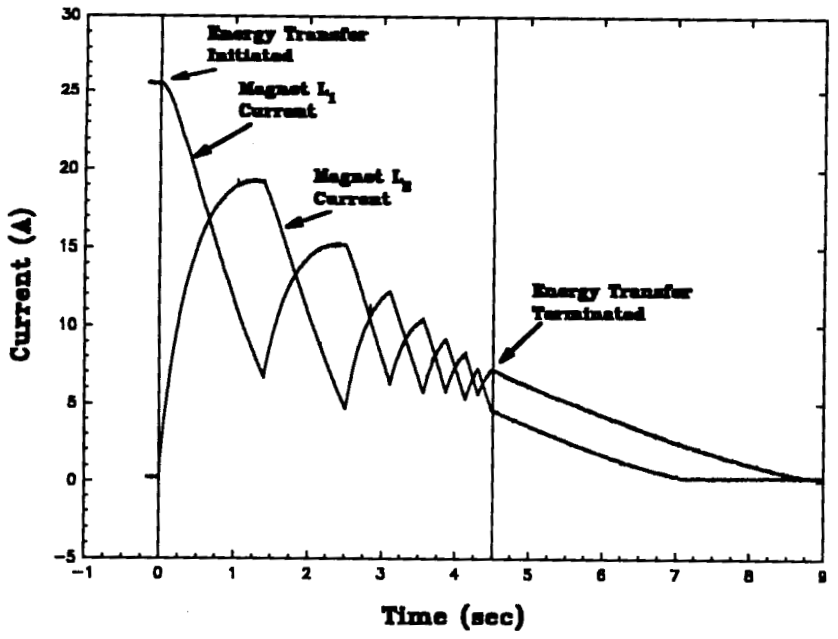


Figure 2. Energy transfer back and forth between two superconducting magnets. In this system the rat of energy transfer and the characteristics, shape of the curves, of how the energy is transferred can be tailored to an applications needs.

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A tradition of excellence!

BRAC Site Visit 3-27-1995
Annapolis Detachment
Commissioner Rebecca Cox

Wrap Up

Tim Doyle

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BRAC Site Visit 3-27-1995
Annapolis Detachment
Commissioner Rebecca Cox

Wrap Up

- Machinery R&D is Necessary
- Machinery Programs are and Will Remain Healthy
- Annapolis R&D Capabilities are Excellent

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MACHINERY R&D HAS A FUTURE IN A DOWNSIZED NAVY

- Compliance with Environmental Initiatives
- Pressure to Reduce Fleet Costs
  - Procurement
  - Operating and Support
- Need to Maintain Qualitative Advantage
  - Stealth
  - Survivability
- Support of Dual Use and Defense Conversion Initiatives

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MACHINERY R&D PRODUCTS PROVIDE IDEAL CANDIDATES FOR DUAL USE AND DEFENSE CONVERSION

Annapolis teaming with Industry and Academia

Examples

- Fuel Cells for Electrical Power
- Composite Material Application
- Applications of Superconductivity
- Low Noise Machinery
- Reduced Cost Pumps, Compressors
- Fault Tolerant Electrical Power Systems
- Advanced Power Electronics
- Ozone-Safe Machinery
- Advanced Electrical Machinery
- Pulsed Power Systems

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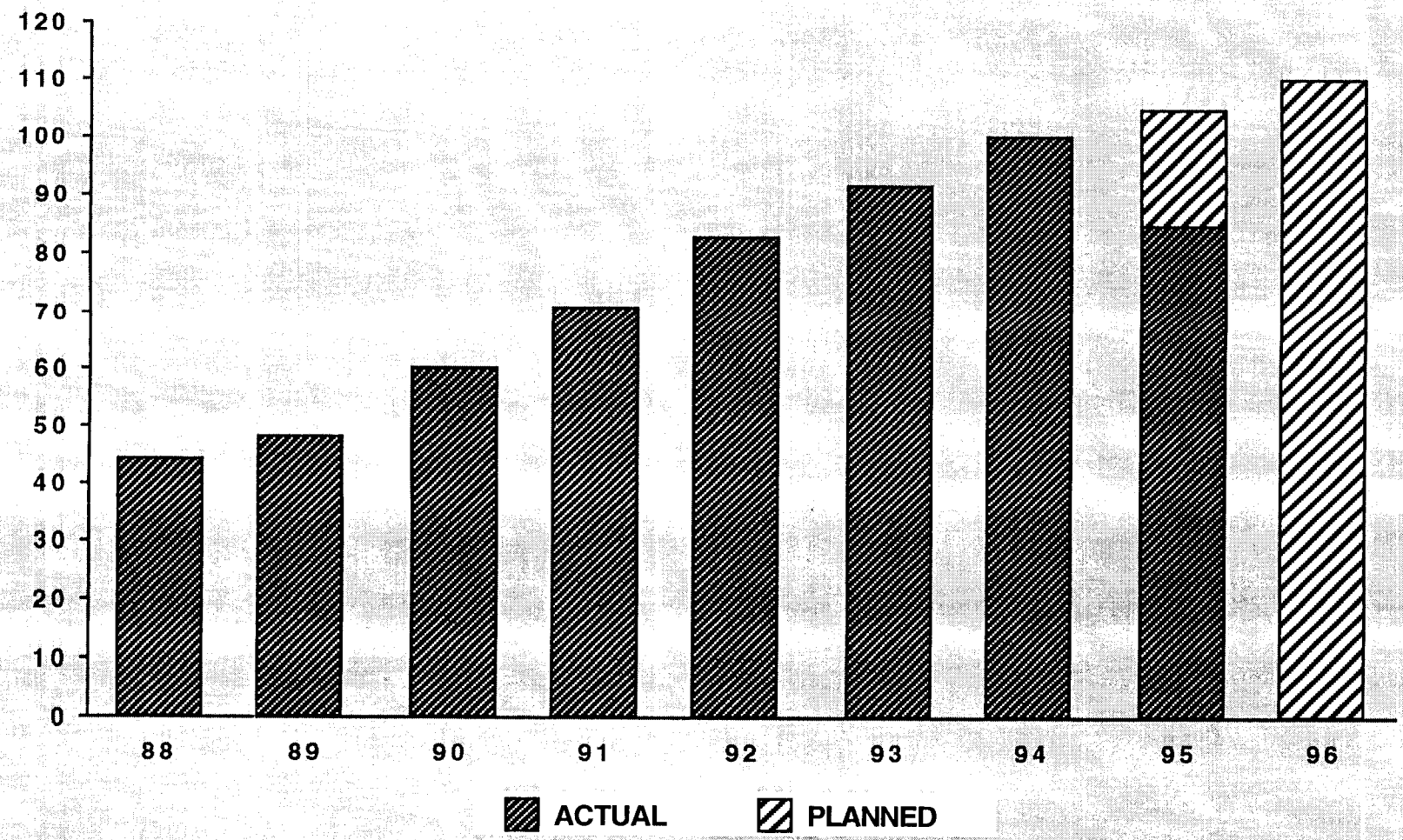
MACHINERY R&D DIRECTORATE

FUNDING TREND



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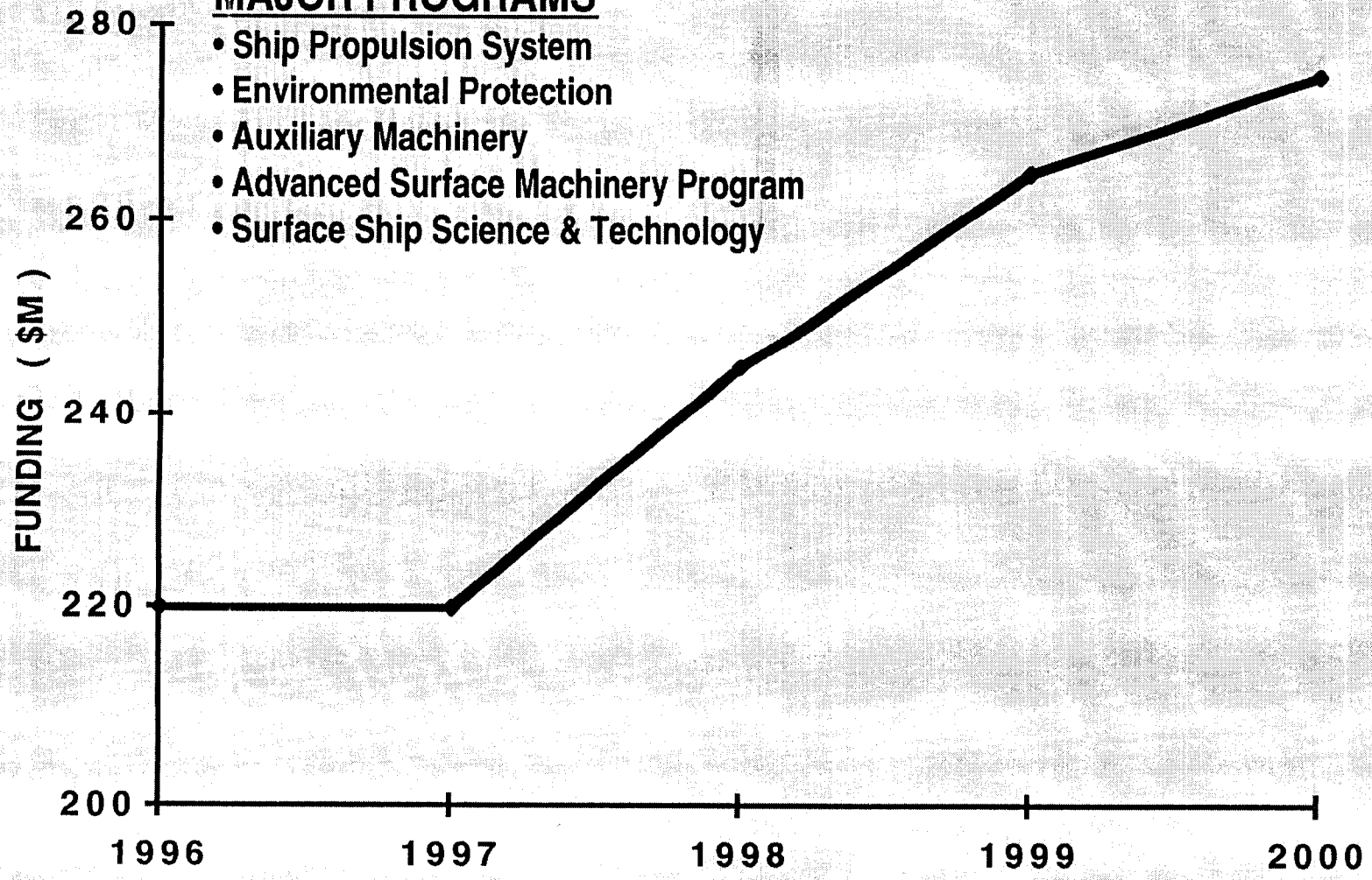
MACHINERY R & D
CUSTOMER PROGRAMS

MAJOR PROGRAMS

- Ship Propulsion System
- Environmental Protection
- Auxiliary Machinery
- Advanced Surface Machinery Program
- Surface Ship Science & Technology



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CARDEROCK DIVISION STRATEGIC PLANNING PROCESS

- *Technical Directorates projected manpower cost of future programs considering benefit in:*
  - *War Fighting*
  - *Readiness*
  - *Dual Use*
- *Directorate models were combined into a Division Manpower Allocation Model*
- *For any Division Propulsion the model identified the distribution which maximizes benefit*

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- *For any Division Propulsion the model identified the distribution which maximizes benefit*

Model Results for Reduced End Strength

Division Population	*-18%*
Machinery R&D	*+4%*

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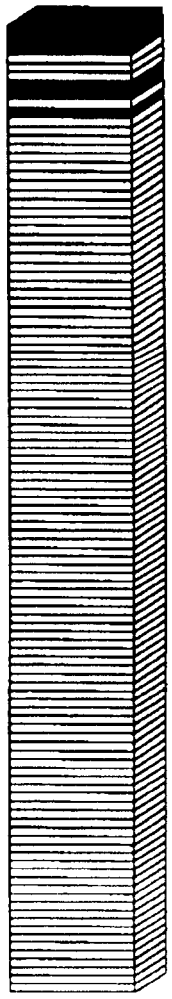
NSWC STRATEGIC PLANNING PROCESS

- 78 Technical Capabilities (TC's) identified for NSWC's five Divisions
- 20 TC's represent the Carderock Division
- Machinery R&D is a principle contributor to 3 (Propulsion, Electrical and Auxiliary Machinery)
- The Military Value of each TC was evaluated by NSWC's Board of Directors considering:
  - Technical Functions
  - Expertise
  - Business Base
  - Jointness
  - Location & Facilities

RESULTS – TECHNICAL CAPABILITIES

RANKING

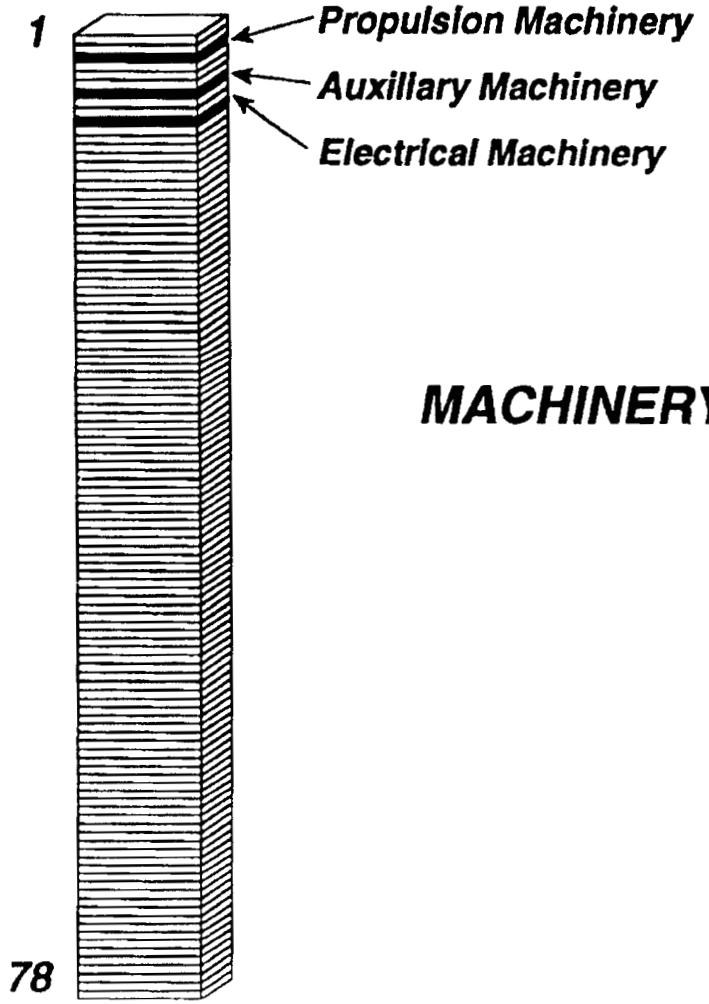


CARDEROCK DIVISION HAS 6 OF TOP 10

#1, 2, 3, 7, 8, 10

RESULTS – TECHNICAL CAPABILITIES

RANKING



MACHINERY TC's ARE #3, 7, 10

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MACHINERY RESEARCH AND DEVELOPMENT FACILITIES SPRING 1993

Operational Facilities

- Advanced Electrical Machinery Systems Facility
- Electrical Power Technology Facility
- Environmental Non-CFC Facility
- Advanced Propulsion Machinery Facility
- Machinery Acoustic Silencing Laboratory
- Submarine Fluid Dynamics Facility
- Shock and Vibration Facility
- Deep Ocean Vehicle and Machinery Pressure Simulation Facility
- Magnetic Fields Laboratory
- Fiber Optics Technology Laboratory
- Electric Power Laboratory

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MACHINERY RESEARCH AND DEVELOPMENT FACILITIES SPRING 1995

Operational Facilities

- Advanced Electrical Machinery Systems Facility
- Electrical Power Technology Facility
- Environmental Non-CFC Facility *(expanding)*
- Advanced Propulsion Machinery Facility
- Machinery Acoustic Silencing Laboratory
- Submarine Fluid Dynamics Facility *(upgrading)*
- Shock and Vibration Facility
- Deep Ocean Vehicle and Machinery Pressure Simulation Facility
- Magnetic Fields Laboratory *(expanding)*
- Fiber Optics Technology Laboratory
- Electric Power Laboratory

New Facilities Construction

- *Pulsed Power Systems Test Facility - Completed March 1995*
- *Shaft Line Component Development Facility - April 1995 Completion*
- *Integrated Power Systems Facility - June 1995 Completion*

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MACHINERY RESEARCH AND DEVELOPMENT SITES VISITED 3-27-1995

Operational Facilities

- Advanced Electrical Machinery Systems Facility
- Electrical Power Technology Facility
- Environmental Non-CFC Facility *(expanding)*
- Advanced Propulsion Machinery Facility
- Machinery Acoustic Silencing Laboratory
- Submarine Fluid Dynamics Facility *(upgrading)*
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MACHINERY RESEARCH AND DEVELOPMENT
BRAC 95 PROPOSALS

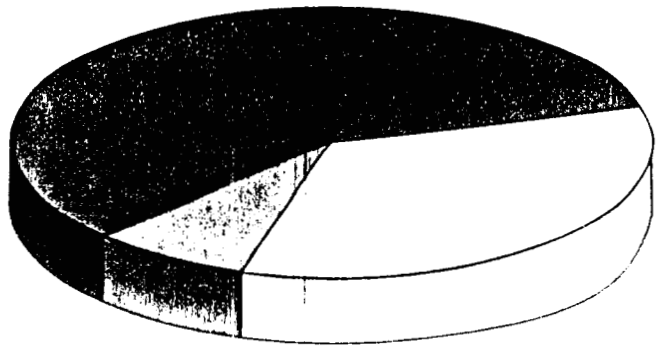
Facility	Proposal
• Advanced Electrical Machinery Systems Facility	- Relocate
• Electrical Power Technology Facility	- Relocate
• Environmental Non-CFC Facility	- Relocate
• Advanced Propulsion Machinery Facility	- Relocate
• Machinery Acoustic Silencing Laboratory	- Relocate
• Submarine Fluid Dynamics Facility	- Abandon
• Shock and Vibration Facility	- Relocate
•Deep Ocean Vehicle and Machinery Pressure Simulation Facility	- Abandon
•Magnetic Fields Laboratory	- Replicate
• Fiber Optics Technology Laboratory	- Relocate
• Electric Power Laboratory	- Relocate
•Pulsed Power Systems Test Facility	- Relocate
• Shaft Line Component Development Facility	- Relocate
• Integrated Power Systems Facility	- Relocate

Machinery R&D Directorate

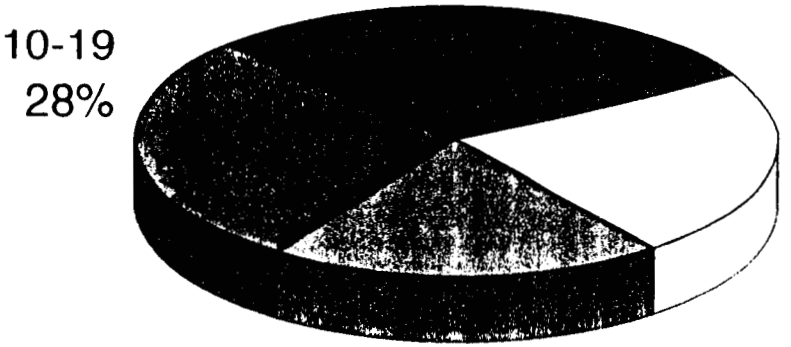
PROFESSIONAL PROFILE

Scientists and Engineers – 308 People

Professional Degrees



Professional Experience (Years)



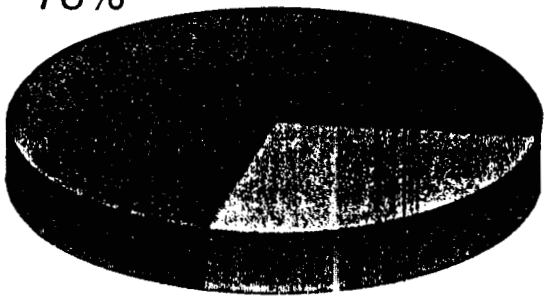
Machinery R&D Directorate

PROFESSIONAL ACTIVITIES

CY 1993

>35 INVENTIONS

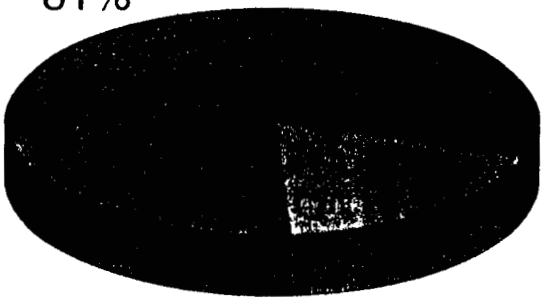
Patent Awards
73%



Disclosures
27%

>200 PUBLICATIONS

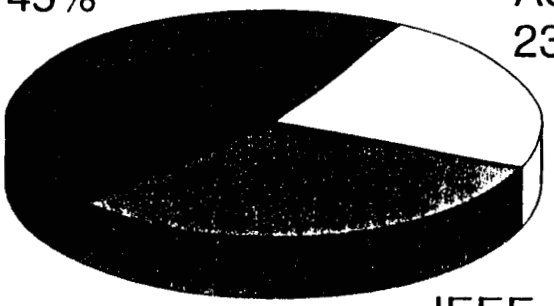
R&D Reports
81%



Papers &
Journals
19%

>200 PROFESSIONAL
SOCIETY MEMBERSHIPS

Other
45%



ASME
23%

IEEE
17%

ASNE
14%

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CONCLUSIONS

- Machinery R & D is Healthy and Must Remain So:
  - Responsive to Need
  - Growing Business Base
  - Top Marks in Strategic Assessments

- Directorate Capabilities are Excellent
  - Experienced, Competent, Dedicated Professional Staff
  - World Class, Growing Lab Facilities

MACHINERY ACOUSTIC SILENCING

(Submarine Acoustic Signature Reduction)

Facilities Provide Essential
Low Background Noise Levels
To Duplicate Submarine
Operating Conditions

- Anechoic Chambers
- Isolating Walls & Floor
- Located Far From Noise
(i.e. Industry)